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SALMON AGE, SEX, AND LENGTH CATALOG FOR THE KUSKOKWIM AREA, 2004

Annual Report for Project 04-307
USFWS Office of Subsistence Management
Fisheries Information Services Division

by

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and

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October 2005

Alaska Department of Fish and Game **Division of Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and Figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

The Kuskokwim Area has the largest subsistence salmon fisheries in Alaska, and in support of these fisheries numerous projects have been funded through the Fisheries Information Services (FIS) Division of the U.S. Fish and Wildlife Service, Office of Subsistence Management to monitor salmon *Oncorhynchus* sp. escapements and subsistence harvest in the region. These projects include collection of samples that are used to estimate age, sex, and length (ASL) composition of salmon escapement and subsistence harvest. The *Kuskokwim Salmon Age-Sex-Length Assessment Continuation* project (FIS 04-307) provides the support required to process these ASL samples and compile the information into summary tables of use to managers, contributing project leaders and other interested parties. The annual product of this project is a series of historical ASL summary tables (ASL Catalog) updated with current year results. This catalog is available at: http://www.cf.adfg.state.ak.us/region3/pubs/pubshom3.php?a=w .

Key words: age-sex-length, ASL, Pacific salmon, *Oncorhynchus sp.*, Kuskokwim River, age class composition, sex composition, length composition.

INTRODUCTION

The Kuskokwim Area as defined by the Alaska Department of Fish and Game (ADF&G), Division of Commercial Fisheries (CF) encompasses waters from Cape Newenham to the Naskonat Peninsula, including waters around Nunivak and St. Matthew Islands (Figure 1). Primary salmon producing systems are the Kuskokwim, Kanektok, and Goodnews Rivers, which drain into Kuskokwim Bay and support runs of Chinook *Oncorhynchus tshawytscha*, sockeye *O. nerka*, chum *O. keta*, pink *O. gorbuscha*, and coho salmon *O. keta*. All five of these salmon species are harvested in area commercial, subsistence, and sport fisheries, as well as various interception fisheries located outside of the formal management area.

Age, sex, and length (ASL) data are collected annually from sampled commercial and subsistence harvests, escapement, run timing and abundance monitoring projects in the Kuskokwim Area. Age, sex, and length data have been collected in the Kuskokwim Area since 1961 (Brannian et al. 2005) and have been cataloged in historical summaries since 1995 (Anderson 1995, Molyneaux and Dubois 1996, Molyneaux and Samuelson 1992). In 2000 subsistence harvest and abundance monitoring projects began as jointly funded and operated by federal, state, and local tribal groups all of which collected ASL data from salmon. The United States Fish and Wildlife Service (USFWS) Office of Subsistence Management (OSM) has assisted funding the processing of ASL data collected in the Kuskokwim Area. Summaries of ASL data have been reported within each project's annual report in addition to a historic catalog maintained by ADF&G. This report functions to provide (1) an overview of the projects collecting data summarized in the ASL catalog, (2) the methods underlying the collection of these data, and (3) results, and trends observed in these data throughout the area. Tables from the ASL catalog are not incorporated into this document due to their number and overall size (128 tables representing 823 pages), but rather are available electronically at: http://www.cf.adfg.state.ak.us/region3/pubs/pubshom3.php?a=w . Lastly, this report represents an annual report for USFWS OSM project FIS 04-307.

OBJECTIVES

The objective for the USFWS OSM project FIS 04-307, *Kuskokwim Salmon Age-Sex-Length Assessment Continuation* is to process, compile, and analyze salmon scales, and sex and length data collected in Kuskokwim Region fisheries and escapement projects. This represents for 2004 datasets from 9 escapement monitoring projects, 1 test fish project, and catch sampling from the Kuskokwim River Chinook salmon subsistence fishery and commercial fisheries in 3 districts.

ESCAPEMENT MONITORING

Annual assessments of salmon spawning escapements are monitored in the Kuskokwim Area with weirs, counting towers, sonar, and aerial surveys (Ward et al. 2003). Ground-based weir, tower and sonar projects typically include ASL sampling, with samples collected from salmon captured with beach seines, traps, or by hook and line. Ground-based projects are typically operated from mid-June through mid-September, which encompasses the majority of the Chinook, chum, sockeye, and coho salmon migration. Ground-based projects are found throughout the drainage (Figure 1) ranging from 216 to 835 river kilometer (rkm) from the mouth (Table 1) of the Kuskokwim River.

Takotna River

The Takotna River joins the Kuskokwim River at river kilometer (rkm) 752 (Figure 1, Table 1). Ground-based salmon escapement monitoring began in 1995 with a counting tower located near the community of Takotna (rkm 832), but no ASL sampling was conducted (Molyneaux et al. 2000). The tower project was replaced in 2000 with a resistance board weir at rkm 83, and project objectives were broadened to include ASL sampling (Schwanke et al. 2001; Schwanke and Molyneaux 2002). The Takotna weir project is conducted jointly by ADF&G CF and Takotna Tribal Council (Clark and Molyneaux 2003; Costello et al. *in prep*; Gilk and Molyneaux 2004). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Tatlawiksuk River

The Tatlawiksuk River joins the Kuskokwim River at rkm 491 (Figure 1, Table 1). Ground-based salmon escapement monitoring began in 1998 with a fixed-panel aluminum weir established 5 rkm upstream of the confluence (Linderman et al. 2004a). The fixed-panel weir was replaced with a resistance board design in 1999 that allowed the operational period to be effectively extended through the coho salmon migration. The Tatlawiksuk weir project is conducted jointly by ADF&G CF and the Kuskokwim Native Association (Linderman et al. 2002, 2003a, 2004a; Stewart and Molyneaux 2005) with funding assistance from USFWS OSM beginning in 2000 (project FIS 00-007 and FIS 04-310). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Kogrukluk River

The Kogrukluk River is located in the upper reaches of the Holitna River drainage, which joins the Kuskokwim River at rkm 491. Kogrukluk River is 218 rkm upstream of that confluence, and the weir is approximately 1 rkm father upstream (Figure 1, Table 1). Kogrukluk River has the most extensive history of ground-based salmon escapement monitoring in the Kuskokwim Area. Counting tower projects were operated on the lower Kogrukluk River from 1969 through 1978 (Baxter 1976, 1977; Kuhlmann 1973, 1974, 1975; Yanagawa 1972a, 1972b). Both a weir and tower was operated from 1976 through 1979 and a weir thereafter (Clark and Salomone 2002; Shelden et al. 2004, *in prep*). ASL sampling of Chinook salmon began in 1972 (Yanagawa 1973). Chum and sockeye salmon were not regularly included in ASL sampling until 1976 when a picket weir was first installed (Baxter 1976). Sampling of coho salmon started in 1981 when the operational period of the weir was extended into August and September (Baxter 1982).

Sampling sockeye salmon for ASL information was discontinued after 1995 because of difficulties in aging the reabsorbed scales and historical data are not included in catalog tables. The project is conducted by ADF&G CF (Shelden et al. *in prep*) supplemented with technicians from Orutsararmiut Native Council. The ASL samples collected from Chinook, chum, and coho salmon are summarized in the ASL catalog.

George River

The George River joins the Kuskokwim River at rkm 446 (Figure 1, Table 1). Ground-based salmon escapement monitoring began in 1996 with a fixed-panel aluminum weir established 7 rkm upstream of the confluence. The fixed-panel weir was replaced with a resistance board design in 1999 that allowed the operational period to be effectively extended through the coho salmon migration (Linderman et al. 2003b, 2004b; Molyneaux et al. 1997). The project is conducted jointly by ADF&G CF and Kuskokwim Native Association (Stewart et al. *in prep*). ASL samples have been collected from Chinook, chum, and coho salmon and are summarized in the ASL catalog.

Aniak River

The Aniak River joins the Kuskokwim River at rkm 307 (Figure 1, Table 1). Ground-based salmon escapement monitoring began in 1980 with the use of non-configurable sonar deployed approximately 16 rkm upstream of the Kuskokwim River confluence (Schneiderhan 1981). The project was redesigned in 1996 to incorporate user-configurable sonar technology, as well as chum salmon ASL sampling with beach seines (Vania 1998). Methods changed again in 2004 to incorporate advances in Dual-frequency Identification Sonar (DIDSON) (McEwen 2005). The reported passage estimates are a mix of species; chum salmon dominate during most of the annual operational period, but the sonar counts are unapportioned to species. The project is conducted by ADF&G CF. ASL samples collected from chum and coho salmon are summarized in the ASL catalog.

Tuluksak River

The Tuluksak River joins the Kuskokwim River at rkm 192 (Figure 1, Table 1). Ground-based salmon escapement monitoring occurred from 1991 through 1994 when USFWS operated a weir at approximately rkm 232 (Harper 1995a, 1995b, 1995c, 1997). With support from the Tuluksak IRA Council, weir operations led by USFWS recommenced in 2001 16 rkm downstream from the previous site (rkm 216) using a resistance board weir (Gates and Harper 2002; Zabkar and Harper 2004; Zabkar et al. *in prep*). For all years of operations, staff from ADF&G CF process ASL samples and provided data summaries to USFWS for inclusion in annual project reports for FIS 01-153 and FIS 04-302. ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

Kwethluk River

The Kwethluk River joins the Kuskokwim River at rkm 131 (Figure 1, Table 1). Ground-based salmon escapement monitoring occurred for one year in 1992 when the USFWS operated a weir at approximately rkm 30 of the Kwethluk (Harper 1998). The Association of Village Council Presidents (AVCP) in cooperation with ADF&G operated a counting tower in place of the weir at a nearby location from 1996 through 1999, but success was limited (Cappiello and Sundown 1998; Chris and Cappiello 1999; Hooper 2001). Weir operations were recommended in 2000 by USFWS in cooperation with the Organized Village of Kwethluk and funding support by USFWS

OSM (FIS 00-019). Since 2000 a resistance board weir was placed at rkm 216 within the same general vicinity (Roettiger et al. 2004, *in prep*). For all years of operations, staff from ADF&G CF process Kwethluk ASL data and since 2000 provide summaries to USFWS for inclusion in annual project reports (FIS 00-019 continued as FIS 04-304). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

Kanektok River

The Kanektok River joins the marine waters of Kuskokwim Bay near the community of Quinhagak (Figure 1). The Kanektok River is the main salmon spawning stream in District 4. Various efforts have been made to incorporate ground-based salmon escapement monitoring in the Kanektok River (tower: ADF&G 1960, 1961, 1962; sonar: Schultz and Carey 1982; Schultz and Williams 1984; Huttunen 1984a, 1985, 1986, 1988), but all were discontinued due to site limitations, technical obstacles and budget reductions. More recently, monitoring initiatives recommenced in 1996 with a counting tower, but success was limited (Fox 1997). Improvements in 1997 allowed for moderate success (Menard and Caole 1998b), but the tower was inoperable in 1998 and 1999. Transition to a resistance board weir at rkm 68 began in 2000, but success was limited until 2002 (Estensen 2002a; Estensen and Diesinger 2003, 2004; Linderman 2000, 2005a). The current weir project is conducted jointly by ADF&G CF and the Native Village of Kwinhagak with funding support from OSM (FIS 01-118 continued as FIS 04-305). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

Middle Fork Goodnews River

The Middle Fork Goodnews River joins the Goodnews River at about rkm 10 (Figure 1). The Goodnews River in turn empties into the marine waters of Goodnews Bay. Ground-based salmon escapement monitoring began in 1981 with the establishment of a counting tower at about rkm 5 of the Middle Fork Goodnews River[1] (Menard 1998; Schultz 1985, 1987; Schultz and Burkey 1989). Annual operating procedures began to include some form of ASL sampling by 1985, with methods including carcass sampling and beach seining. The tower project was replaced with a fixed panel aluminum weir in 1991, and then with a resistance board weir in 1997 that allowed for operation through the pink and coho salmon migrations (Estensen 2002b, 2003; Linderman 2005b; Menard 1998, 1999, 2000; Stewart 2004). The project is operated by ADF&G CF with funding support by OSM (FIS 00-027 continued as FIS 04-312). ASL samples have been collected from Chinook, chum, sockeye, and coho salmon and are summarized in the ASL catalog.

COMMERCIAL FISHERIES

The Kuskokwim Salmon Management Area is currently divided into four commercial fishing districts (Figure 1). The boundaries of these districts have changed over the years as described in annual management reports (e.g., Burkey et al. 1998, 1999; Ward et al. 2003). District 1 is located in the lower Kuskokwim River and currently extends from Kuskokwim Bay to Bogus Creek, a distance of 203 km. District 2 spans a distance of approximately 60 km in the middle Kuskokwim River, currently extending from near Kalskag to Chuathbaluk. District 4 is located

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[1] In the literature the Middle Fork Goodnews River weir /tower are often misleadingly referred to as the “Goodnews River weir/tower”; in actuality the project has always been located on the middle fork of the Goodnews River.

in the marine waters of Kuskokwim Bay near the community of Quinhagak and is managed as a terminal fishery supported by the salmon production of the Kanektok River, the principle salmon-producing stream draining into that district. District 5 is located in Goodnews Bay and is also managed as a terminal fishery supported by the salmon production of the Goodnews River.

Drift gillnets are the principal gear type used in all Kuskokwim Area commercial salmon fisheries, although set gillnets were common in some locations during the early development of the fisheries (Ward et al. 2003). Prior to 1985, commercial fishers in the Kuskokwim River were unrestricted as to the gillnet mesh size they used, and many used 8 or 8.5 inch (20 or 22 cm) mesh sizes during the June Chinook fishery. Commercial gillnets are currently restricted in all Kuskokwim Area fishing districts to mesh sizes of 6 inches (15.2 cm) or smaller. Commercial fishers in Kuskokwim Bay districts have been restricted to the smaller mesh sizes since the inception of those fisheries. Results from commercial catch sampling described in this catalog are from restricted mesh openings unless stated otherwise. ASL samples collected from Chinook, chum, sockeye, and coho salmon from Districts 1, 4 and 5 are summarized in the ASL catalog.

BETHEL TEST-FISHERY

A drift gillnet test fishery was established on the mainstem Kuskokwim River near Bethel in 1984 to provided fishery managers with a daily index of salmon abundance and run timing (Bue 2005; Molyneaux 1998). Located at rkm 106, the project is at about the midpoint of District 1. From early June through late August the crew conducts three or four systematic gillnet drifts beginning one hour after high tide. The drifts are done at three stations distributed across the width of the channel. Each drift is 20 minutes in duration. Two 50 fathom gillnets are used, one net is hung with 5-3/8-inch mesh web and the other with 8-inch mesh. The two gillnets are rotated between the three stations following a systematic schedule. Both mesh sizes are operated from early June through about 10 July when Chinook, sockeye and chum salmon all occur. The 8-inch mesh is discontinued after about 10 July when Chinook abundance diminishes. Test fishing with the 5-3/8-inch mesh continues until late August. Collection of ASL information from the test-fish catch has been sporadic and limited to more recent years. ASL data from Chinook, chum, sockeye, and coho salmon are summarized in the ASL catalog.

Historically, other test fisheries have been attempted in the Kuskokwim River: Kwegooyuk test fishery, 1966 - 1983 (Baxter 1970; Huttunen 1984b); Eek test fishery, 1988 to 1994 (unpublished); Kuskokwim River subsistence test fishery, 1988 to 1990 (Kuskokwim Fishermen’s Cooperative 1991); Aniak test fishery, 1992 to 1995 (unpublished); Chuathbaluk test fishery, 1992 to 1993 (unpublished); and the Lower Kuskokwim River test fishery, 1995 (unpublished). Most were initiated at the prompting of groups other than ADF&G, and all were eventually discontinued. Some of the projects incorporated salmon ASL sampling, but the results are not currently reported in our ASL catalog.

SUBSISTENCE FISHERIES

The Kuskokwim Area supports the largest subsistence salmon harvests in the State of Alaska (ADF&G 2003), and is a prominent and vital element to the culture of many local residents (Coffing 1991, 1997; Oswalt 1990). Subsistence harvest occurs throughout the Kuskokwim Area, but most effort and harvest occurs in the lower 203 rkm of the Kuskokwim River in District1 (Figure 1, Table 1). Gear types used by subsistence salmon fishers include drift and set gillnets, fish wheels, rod and reel, seines, and spears; however, drift gillnets are overwhelmingly the most common contemporary gear type (Coffing 1997). Unlike commercial fishing, there is no restriction on the mesh size used in subsistence gillnets, and many fishers choose 8.0 or 8.5-inch (20 or 22 cm) mesh sizes to target larger Chinook salmon. Chinook salmon are the only species sampled for ASL information from the subsistence harvest, and most sampling is limited to the Kuskokwim River (Figure 1).

Modest efforts to collect complete ASL data from subsistence caught Chinook salmon occurred in 1993, 1994, and 1995 as a pilot project (DuBois and Molyneaux 2000). The initiative was discontinued due to a lack of resources to execute the program. The program was re-established, and expanded, in 2001 through resources provided by the OSM in coordination with ADF&G CF and various Tribal organizations (DuBois et al. 2002). For 2001 through 2003, 3 projects were funded by OSM, FIS 01-023 for the upper river, FIS 01-225 for the middle river and FIS 01-132 for the lower river (Molyneaux et al. 2004a, 2004 b). Only the project for the lower Kuskokwim River continued in 2004 (Molyneaux et al. 2005). The ASL catalog contains summaries for Chinook salmon samples collected 1993 through 1995 and more complete summaries for data collected since 2001.

SPORT FISHERIES

Sport fishing activity is relatively low in the Kuskokwim Area, still moderate effort does occur in a few specific locations such as the Kanektok, Goodnews, Kisaralik and Aniak Rivers (Howe et al. 1996). Professional guiding outfits focus mostly on these four river systems, but there are a growing number of guides expanding into other locations such as the Holitna, George, Oskawalik and Holokuk Rivers. Collection of ASL information from sport harvest is limited and not reported in the catalog.

METHODS

If viewed from a fixed location, such as an escapement-monitoring project or a fishing district, the ASL composition of an upriver-migrating salmon population often changes over the course of the season. This can arise as differences in the timing of migration exists among Kuskokwim River salmon stocks (Pawluk et al. *in prep*; Stuby 2005). Furthermore Quinn (2005) describes an often observed pattern of older or larger fish often preceding smaller fish on the migration. Each year, salmon are sampled at such locations to estimate the ASL compositions of the respective escapement or catch. Pulse samples of ASL information are collected periodically over the duration of the migration to account for the temporal changes in the ASL composition. Ideally, a series of several well distributed pulse samples are collected for each species to characterize each escapement or catch. Each series should include at a minimum three pulse samples representative of the early, middle and late portions of the run. Collecting additional pulse samples allows for greater resolution in detecting temporal changes in the ASL composition, and greater reliability in characterizing the true composition of the escapement or catch. For populations whose ASL composition changes over the course of the season, pulse sampling has a greater power of detecting that change than does random sampling, systematic sampling, or too closely spaced “grab” samples (Geiger and Wilbur 1990).

Each pulse sample is assigned to a temporal segment, or strata, of the run, which the sample is intended to characterize. For in-season purposes, each temporal stratum approximate one week in duration, but the actual number of days included in a stratum are defined post-season depending on sampling success. The age-sex composition of the sample is then applied to the fish passage, or harvest, that occurs in each stratum. This yields an estimate of the number of fish, of each age-sex class in the escapement or harvest for each stratum. The apportioned fish in each stratum are then summed by age and sex to estimate the composition of the population for the entire season. Average fish length for the season is described by age and sex, and derived by weighting the average length in each stratum by the number of fish represented by that stratum. These procedures yield weighted season estimates of the salmon ASL composition for each project or fishery.

SAMPLE COLLECTION

Sample Size

The sample size of each pulse is determined following conventions described by Bromaghin (1993). The sample size goals for each stratum by species are: 210 Chinook, 210 sockeye, 200 chum and 210 coho salmon. The sample sizes vary between species due to differences in the number of major age-sex groupings to be distinguished. These sample sizes were selected so that the 95 percent confidence intervals for simultaneous estimates of age composition proportions would be no wider than 0.10 (α = 0.05 and d = 0.10). Recommended sample sizes were increased by 8 to 9 percent to account for fish whose age could not be determined due to sampling error or illegible scales. Considering the dynamics of the ASL composition, the need for achieving the sample goals are weighed against the need for collecting each pulse sample over a relatively brief period of time; consequently, the sample goals serve as guidelines rather than rigid requirements.

General Sampling Procedures

Sampling routine includes the removal of scales from the preferred area of the fish for use in age determination (INPFC 1963). Generally one scale is taken from each sockeye and chum salmon, but three scales are taken from Chinook and coho salmon to account for regeneration of freshwater annuli. At some escapement projects, where scale absorption can be problematic, multiple scales are taken from chum salmon. All scales are mounted on gum cards. Except where noted, sex is determined by visually examining external morphological characteristics such as development of the kype, roundness of the belly, presence or absence of an ovipositor, and overall size. Length is measured to the nearest millimeter from mid-eye to the fork of the tail by some straight-edged tool like calipers, meter stick, or fish cradle. Some data sets, especially commercial samples prior to about 1991, may include measurements taken with cloth tapes, in which the measurement includes the body curvature. Data are recorded in field notebooks or tally sheets, on computer mark-sense forms, or logged electronically on a computerized fish measuring board or hand held data logger. The original scale cards, acetates and data forms are archived at the ADF&G office in Anchorage.

Escapement Sampling

Escapement ASL samples are collected from salmon passing weirs, counting towers, and tributary sonar sites. The goal is to estimate the seasonal ASL composition of the spawning population of a given tributary. Weir samples are generally obtained from traps built into the weir. Beach seines or gillnets are used at counting towers and sonar sites. The sample sizes and sampling frequency have varied over the years. During some years, a small number of fish were sampled each day, in others a larger daily sample was taken until a pre-determined sample size was achieved for the week. Since 1993, area staff has employed the latter method where fish are sampled in pulse samples over a short time interval (i.e., one to several days) followed by a number of days without sampling. These pulse samples are taken several times (minimum goal of three) throughout the season to create a series of "snap-shots" of the ASL composition. Most project reports include a detailed description of ASL sampling protocols.

Commercial Catch Sampling

Commercial salmon harvest is sampled for ASL data as fishers deliver their catch to floating and shore-based processors located near Bethel, Quinhagak and in Goodnews Bay. The goal is to estimate the season ASL composition of the population of fish harvested in the District 1, 4, and 5 commercial fisheries. Commercial catches are generally sampled after the salmon are off-loaded from the fishing boats. Off-loading crews typically place each salmon in a species-specific tote with no regard to sex, size or stage of maturity. ADF&G's sampling crews sample fish from these totes. In Kuskokwim Bay the crews sometimes obtain samples from the tender hold or individual boats as deliveries are made. In either case, the sample from each day generally includes fish from several boats, but this variable is not monitored and in some instances a sample may come from as few as two or three boats. Samples from Kuskokwim Bay have a greater likelihood of coming from small numbers of deliveries because of the limited resources available for collecting samples. The mesh size used by fishers varies, but it is assumed to be within the legal range of specifications. Time and logistical constraints prohibit interviewing fishers for information regarding mesh size or the exact location fish were caught. Department crews are instructed to sample in a manner which guards against size or sex bias; this usually entails sampling all the fish from an individual tote, particularly for Chinook salmon.

Sex was confirmed in most salmon sampled from the commercial fishery starting in 1997. Sex identifications are done by making a small incision into the abdominal cavity of each fish to visually inspect for the presence of ovaries or testes. Strata with confirmed-sex fish are identified in the appropriate tables by footnotes.

Subsistence Catch Sampling

Until recent years the Chinook harvest of a few subsistence fishers were sampled each year. Most samples were collected from the Bethel area, but in a few instances samples have also been collected from the Aniak area. Prior to 1992, samples were limited to scales removed from fish that were hanging on drying racks. Sex and length could not be determined and details about the harvest method were lacking. In 1992, fish were sampled in the round and included sex and length information. In 1993 through 1995, a small group of subsistence fishers was recruited and trained to collect ASL data from their catches. The fishers collected three scales from each fish, and recorded sex as determined by internal examination of gonads, and length as determined with a meter stick. The fishers also recorded gear type (e.g., set net or drift gillnet), mesh size, date of capture and the location of capture. Fishers received monetary compensation for the samples. The program was discontinued in 1996 due to difficulties in recruiting participants and the time required for training and inseason follow-ups.

An ASL sampling program for subsistence caught Chinook salmon was reinstituted in 2001 in cooperation with non-government organizations, and non-agency participants that included subsistence fishers, subsistence household members, or other community members who sampled fish caught near their local communities or fish camps (Dubious et al. 2002; Molyneaux, et al. 2004a, 2004b 2005). Participants were trained in sampling technique by technicians and biologists from ADF&G or one of several non-government cooperating groups such as

Orutsararmiut Native Council. Participants collect samples from their own catch and or the catches of others. Sample limits (number of fish samples) were not placed on individual participants though participants were selected as being willing to sample all season, sample all fish during each event, and were encouraged to sample other fish camps. Participants collected three scales from each fish, and recorded sex as determined by internal examination of gonads, and length as determined with a meter stick. Participants also recorded gear type (e.g., set net or drift gillnet), mesh size, date of capture and the location of capture. Participants received monetary compensation for the samples.

DATA PROCESSING AND REPORTING

Age Determination

Age is determined from the annuli of scales taken from the preferred area of the fish (INPFC 1963). The scales, which are mounted on gum cards, are impressed in cellulose acetate using methods described by Clutter and Whitesel (1956). The scale impressions are magnified with a microfiche reader and age is determined through visual identification of annuli. Ages are reported on data forms or directly entered into computer ASCII files. Since 1985, all ages have been recorded using European notation[2], but Gilbert-Rich notation[3] was typically used prior to 1985. In this report all ages are reported in European notation.

Length information is helpful in determining ages of absorbed or otherwise questionable scales, especially with Chinook salmon, which have a more distinctive range of lengths for each age class than other salmon species. When aging a Chinook salmon scale, length at age is compared to historic length at age for that project or district using length summary tables. Lengths that fall outside of the range are noted as questionable. When all Chinook salmon have been aged for a particular area a length frequency histogram is compiled for that area. The questionable ages are then reexamined using the corresponding length frequency histogram. Some of the questionable ages are then matched to the expected length at age. Length at age is also useful to determine questionable ages with chum salmon, but to a much lesser degree than with Chinook salmon. Length at age is not generally used when aging sockeye or coho salmon.

Computer Processing Format

Most ASL information from recent years is recorded on computer mark-sense forms that are processed through an OPSCAN machine to produce ASCII computer files. Portable data recorders were first used in the 1998 season and a more bulky fish measuring board has also been used in recent years. The data recorder produces an ASCII file similar to the OPSCAN raw data file. Data from the fish measuring board must be parsed to produce comparable ASCII files. The ASCII files are then processed through a number of programs to produce various summaries. One summary focuses on the age and sex composition, another focuses on length statistics by age and sex. Where applicable, the information is applied to escapement and catch data to provide an estimate of the total age, sex, and length composition of those populations.

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[2] In European notation two digits are separated by a decimal and refer to the number of freshwater and marine annuli respectively. The first digit represents the freshwater age minus one. The second digit represents the number of annuli formed during the marine residency. Total age from brood year is the sum of the two ages plus one.

[3] In Gilbert-Rich notation two digits are listed without a decimal. The first digit represents the total years of life at maturity and the second number, which is usually subscripted, denotes the years of life after out-migration from freshwater.

Strata Determination

The term “stratum”, as most often used in this catalog, is a defined time interval during which fish pass a given point such as a weir or tower project, or are harvested from a given location such as District 1. The time interval usually spans approximately 7 days, but the duration may vary from one stratum to the next. For example, the first stratum for chum salmon at a weir project may extend from 18 through 30 June, while the second stratum is from 1 to 6 July. The entire season is partitioned post-season into several strata based on the number and temporal distribution of ASL samples. Collectively, the strata set for a given species encompass the entire annual passage or harvest at a given location.

The ASL composition of a stratum is estimated from fish that are sampled at some time within that stratum. The samples may have been taken evenly throughout the stratum, from the midpoint, or weighted towards one end of the time interval. In practice, the sample distribution is driven by fish abundance and the availability of resources to sample the fish. For example, early in the season when fish abundance is low for a given species, a stratum may span ten to twenty days although most of the samples are collected from only the last few days when the crew is able to catch fish for sampling. For this reason, tables used in this catalog list both the sample dates and the stratum dates.

Although samples are collected with a strata framework in mind, the final partitioning occurs post-season when the distribution of samples can be viewed in context with the overall distribution of the population. Given that sample sizes often fall short of the goal, the partitioning is subjective. The guiding philosophy is that the information be presented in a manner that allows users of these data to decide whether pooling strata with small sample sizes is warranted given the specific needs.

Generally the season’s ASL composition for escapement or harvest populations are estimated only when the distribution of samples allow, at a minimum, strata representing each third of the annual passage or harvest. This “rule of thirds” is necessary due to the seasonal dynamics in the ASL composition of most species. When the rule is not achieved, the sample results are presented in the catalog, but no season estimates are reported. The rule does not apply to season estimates of commercial harvest when fewer than three commercial fishing periods occurred in a season (e.g., District 1 chum salmon in 1993).

Summary Types

The catalog consists of two types of tabular summaries, one that describes data by age and sex composition, and another that summarizes length data by age and sex. Each table lists the year, sample dates, the stratum dates, and the number of fish sampled in each stratum. Sample dates are noted with a footnote when the sex of fish was confirmed through examination of the gonads.

Age/Sex Tables. Age-sex tables describe the age and sex composition for each temporal stratum as a percentage based on the stratum sample. These percentages are used to estimate the number of fish in each age-sex category for the escapement or catch that occurred during the stratum.

Season estimates are weighted by the abundance of fish passage or harvest in each temporal stratum. The escapement or harvest numbers listed in the season summaries are the sum of the stratum estimates. The sums are in turn used to calculate the season percentages. Grand total escapement or harvest estimates are the sum of the annual season estimates. The grand total sums are then used to derive the grand total percentages.

Length Tables. Data in the length tables are summarized by age class and sex. Sample dates and stratum dates are usually identical to the age-sex tables. The length tables include statistics on mean length, standard error, and the range of lengths in each age-sex category. The mean length reported for the season is weighted by fish abundance in each stratum. The weighting is derived by multiplying the mean length of each stratum by the estimated catch or escapement for that stratum. These numbers are summed for all strata in the season then divided by the total estimated catch or escapement for the season. The resulting number is the estimated season mean length for each age-sex category. The mean length reported in the grand total is the average of the annual season mean lengths.

Age, Sex, and Length Catalog

The ASL catalog (tables) was created from a series of Excel spreadsheet tables which were imported into an Adobe PDF file. Each Excel spreadsheet consisted of an historical age-sex table and an historical length table. Each historical table includes data summaries for each year of sampling and includes the within year temporal stratification. A "Grand Total" was calculated across only those years with sufficient ASL sampling and those years are noted in table specific footnotes. The composition of the Grand Total was calculated after summing across each years total by age and sex category to get a Grand Total by age-sex category. Those numbers were then used to calculate percentages by age-sex category. Because of the volume of the catalog it was our intent to minimize paper versions, automate its creation, and post in on the ADF&G Kuskokwim Area web site. In contrast this manuscript will be readily available in paper version and is therefore intended to be published without the accompanying tables.

Age, Sex, and Length Database

Historical data from ASL sampling now reside in a database within the AYK salmon database management system (Brannian et al. 2004, 2005). Data are stored as individual fish. Currently, requests for data must be filled by Information Technology staff. Beginning in June 30, 2007 a web based application will allow the general public extract ASL data. OSM funding for project 04-701 is partially supporting completion of the database management system and web applications.

RESULTS

Tables included in the 2004 ASL Catalog are organized into four major sections based on species: Chinook (Tables 1-52), followed by sockeye (Tables 53-72), chum (Tables 73-100), and coho salmon (Tables 101-128) data summaries. Within each species section, the tables begin with escapement projects, followed by commercial summaries, then test fishery samples, and finally subsistence summaries. Each of these categories is in turn organized by location, generally starting with the farthest interior and progressing towards the coast (river mouth), then south along Kuskokwim Bay. Some escapement, test-fish, and subsistence samples are also arranged by gear type such as 8.0-inch drift gillnets or 6.0-inch set gillnets. For each species, project type, and project location combination the historical age composition table precedes the historical length table.

As described in the preface, the tables presented in the ASL Catalog (Table 2) are not exhaustive of all the data collected from the Kuskokwim Area. For example, data sets are not included from the South Fork Salmon River (Pitka Fork drainage) where a weir was operated in 1981 and 1982 (Schneiderhan 1982a and 1982b).[4] Many of these data summaries reported in the ASL Catalog are also incomplete. As time and resources allow, it is the intention of the authors to continue adding the missing information often representing historical years to future catalog editions. Sources for some of the available information include the *Catch and Escapement Statistics Report Series*, annual management reports and annual project reports. Partial summaries of sport caught fish and carcass samples can be found in Marino (1989), Lisac and MacDonald (1995), Dunaway (1997), and MacDonald (1997). These documents are generally limited to individual years and the methods used to expand the ASL information to escapement and catches generally differ from the methods used in this *ASL Progress Report*.

Users of the historical *Catch and Escapement Report Series* (e.g. Andersen 1985; Huttunen 1989) should be cautioned that the season summaries listed in those reports are weighted by the number of fish sampled rather than the escapement or catch in each stratum as is currently done. The latter method is considered an improvement in that it better accounts for seasonal changes in ASL compositions relative to sampling effort and fish abundance.

DISCUSSION

TRENDS IN AGE, SEX, AND LENGTH COMPOSITION

This section is intended to provide examples of data concerns and common trends found in salmon ASL information in the Kuskokwim Area. Our analysis is not intended to be exhaustive across projects. Project leaders are encouraged to use the examples described herein as the basis for expanding ASL discussions in their annual reports specific to their projects.

SOURCES OF BIAS

Sampling Design

Salmon populations often demonstrate distinctive and dynamic trends in their ASL composition over the course of a single season and it is vital that sampling designs recognize and account for both temporal and spatial variability (Clutter and Whitesel 1956). Sampling effort should be distributed throughout the migration and results weighted in a manner that accounts for fish abundance. Resources or sampling conditions sometimes preclude adequate sampling effort, in which case the available data should not be used to characterize the entire population unless there is clear and justifiable reason to do so. Such incomplete data sets are presented in the ASL Catalog only for the purpose of providing whatever insights may be gleaned from these truncated segments of the populations.

Pulse sampling began to be implemented in the Kuskokwim Area in the early 1990s as a means of accounting for temporal variability in populations. Much of the ASL data reported in the summary tables from years prior to the 1990s have been restratified into a pulse sample format, so results presented here may differ from those originally reported.

[4] In the literature the South Fork Salmon River weir is misleadingly referred to as the “Salmon River weir”; in actuality the weir was located on the south fork of the Salmon River.

Carcass Sampling

The use of carcasses for estimating the ASL composition of spawning escapements can be misleading. Male Chinook salmon, for example, tend to drift downstream in a moribund state after spawning while females tend to remain near their redds (Kissner and Hubartt 1986). As a result, estimates of ASL composition based on Chinook carcasses collected at weirs tend to be biased towards males (McPherson et al. 1997). Data collected at the Middle Fork Goodnews River weir in 1996 and George River weir in 1997 support this conclusion (Figure 2).

By default, estimates based on stream bank carcass surveys would be biased towards female Chinook salmon. The likelihood of this happening is enhanced by the large size of females, which makes them more visible than smaller males. Evenson (1991) and Skaugstad (1990) found that not to be the case when rigorous sampling designs are employed as was done in their stream bank surveys of the Chena and Salcha Rivers (Yukon River drainage). Not withstanding these findings, collecting and interpreting Chinook carcass sample data should be done with caution. Casual or opportunistic sampling is likely especially prone to bias.

For other species, the differential arrival time to spawning grounds that occur between sex and age groups is another potential source of bias in carcass sampling. Temporal dynamics in age composition can be pronounced in sockeye and chum salmon (Quinn 2005). Likewise, changes in sex composition can be pronounced in chum and coho salmon. Other temporal and spatial variations in ASL composition exist in salmon as well. In general, carcass sampling is not recommended as a means of estimating the ASL composition of escapement populations unless sampling designs can account for the inherent dynamics of populations.

Scale Absorption

The phenomenon of scale absorption can make aging of escapement samples unreliable. The margin of a salmon scale is absorbed by the fish as an energy reserve during the last few weeks of life (Clutter and Whitesel 1956). Absorption is most prominent along the lateral edges of a scale. When viewed for aging there may be little or no remnant of the outer annulus remaining on an absorbed scale. The general convention when estimating the age of a salmon from scales is to only use observable annuli, but on occasion, when there is reason to believe a full annulus has been absorbed, the technician or biologist may add an additional year for the missing annulus. Length information is used to help decide the correct age, particularly with Chinook salmon.

Scale absorption in Kuskokwim Area salmon is most problematic in fish sampled from the Kogrukluk River, particularly sockeye salmon. The Kogrukluk River is located approximately 710 rkm from the mouth of the Kuskokwim River (Figure 1). It is farther interior than any other project where ASL data are collected (except the Takotna weir), and scale absorption generally appears more advanced than elsewhere in the area. Consequently the uncertainty of age estimates is heightened.

In their study of British Columbia sockeye salmon, Clutter and Whitesel (1956) reported that the degree of scale absorption varied between individuals and was most pronounced in males. This appears to be true of Kogrukluk River sockeye salmon as well. The degree of scale absorption observed in Kogrukluk River sockeye salmon contributed to the decision in 1995 to discontinue sampling sockeye salmon at that project. Scale absorption is more moderate elsewhere in the Kuskokwim Area and the confidence of age determination is correspondingly greater.

Sex Determination

Secondary sexual characteristics become progressively more obvious in salmon as they near their spawning grounds. Generally an experienced technician at an escapement project can easily and reliably identify the sex of fish. The task is not as reliable when sampling fish from the commercial harvest. Sexual dimorphism is not always obvious in commercially caught fish and use of characteristics such as kype development are not reliable. Male Chinook salmon, for example, may lack a prominent kype while female coho salmon sometimes have pronounced kype development. Both cases are contrary to the common perception that kyped fish are male while unkyped fish are female. Erroneous sex determination is believed to have compromised the reliability of sex compositions described for the commercial Chinook harvests in Districts 4 and 5, where many age-1.2 Chinook where likely incorrectly identified as female prior to the institution of methods to confirm sex in 1997 (Figure 5).

The sex of a salmon can be easily confirmed by an examination of the gonads, but this requires cutting the fish and concerns about market quality generally limit the degree to which this can be done when sampling commercial catches. However, beginning in 1997 staff received permission from salmon buyers to make small incisions in fish for sex confirmation during normal ASL sampling. Nearly every fish sampled from the commercial catch was examined in this way. These samples are identified in the appropriate tables with footnotes. The sex of Chinook salmon sampled from the subsistence harvest in the Kuskokwim River since 2001 are also validated by examination of gonads (Molyneaux et al. 2005).

CHINOOK SALMON

Age Composition

Most Chinook salmon return to the Kuskokwim Area at age-1.2, -1.3, or -1.4 (Molyneaux and DuBois 1999). Commercial fishers harvest these three age classes in fairly even proportions when their gillnets are restricted to mesh sizes of six inches or smaller. From 1974 to 1999 the age composition of the District 1 commercial harvest from fishing periods with restricted mesh size averaged 35% age-1.2, 35% age-1.3 and 25% age-1.4 fish (Figure 3). However, for commercial fishing periods with unrestricted gillnet mesh sizes, as was allowed prior to 1985, the age composition was 3% age-1.2, 36% age-1.3 and 56% age-1.4 (Figure 4). During the unrestricted periods fishers often used large mesh sizes such as 8 inch mesh to target the larger Chinook salmon. Larger mesh sizes continue to be popular among subsistence fishers.

The age composition of the commercial harvest with restricted mesh size coupled with the subsistence harvest with unrestricted mesh size together probably more closely approximate the true age composition of returning Chinook salmon than when both fisheries use unrestricted mesh sizes. Given evidence of the genetic heritability of age at maturity (Hankin et al. 1993), high exploitation rates with large gillnet mesh sizes would likely exert enough selective pressure on the Chinook population to direct the evolution of the species towards smaller, younger fish if continued over many generations. As such, it is in the better interest of species conservation to continue to restrict the commercial fishery to smaller mesh sizes.

In their review of trends in salmon size throughout the North Pacific, Bigler et al. (1996) reported that the mean age at return for Chinook salmon in the Kuskokwim River decreased significantly ($P < 0.01$) between 1975 and 1993. However, the authors based their conclusion on commercial catch data. The decrease was most likely more a result of the 1985 gillnet mesh size restriction described above, than increased salmon abundance at sea as suggested by the authors. Most of the decrease occurred after 1985, which reinforces the alternative explanation. The same study showed no change in the mean age in Yukon River Chinook salmon, and an increase in the mean age of the Kenai River population. A similar retrospective analysis of Yukon River Chinook salmon by Hyer and Schleusner (2005) was less conclusive, the authors noting that relatively short time series of comparative data sets as being the major obstacle to identifying definitive conclusions.

Sex Composition

Females are generally less abundant than males in the Chinook salmon populations returning to the Kuskokwim Area. Female Chinook salmon at Kogrukluk River are estimated to comprise 30.7% of the escapement reported from 1984 to 2004. Information from other streams is less extensive, but the Takotna, Tatlawiksuk, Tuluksak, Kwethluk, Kanektok, and Middle Fork Goodnews Rivers averaged 27.2%, 34.5%, 25%, 19.1%, 29.6% and 35.8% females. Results from the George River shows more even ratios with females comprising 48.3% of the returns. The female fraction of the commercial harvest in Districts 1, 4 and 5 average 29%, 36% and 31% (Figure 3) for fishing periods with gillnet mesh size restricted to 6 inches or smaller. For District 1 periods with unrestricted mesh size, the percentage of females increases from 29% to 43% (Figure 4). Data from subsistence harvests also tend to show fewer numbers of females in the catch even when large mesh gillnets are used.

The sex ratios reported from escapement projects are generally believed to be reliable due to advanced development of sexual dimorphism. Sex ratios reported from the commercial harvest, however, may not be as reliable due to less obvious dimorphism. Most of the Chinook salmon sampled from commercial catches from 1997 through 1999 were investigated internally to verify the sex (Dubois and Molyneaux 2000). Considering only those fish in which the sex was confirmed (N = 3,704), age-1.2 Chinook salmon were found to be overwhelmingly male; 98 percent or more (Figure 5). In samples collected without sex verification the fraction of age-1.2 Chinook reported as male has been as low as 30 percent. Similar trends were found in age-1.3 Chinook where the occurrence of males was 82 percent or greater when sex was verified, but as low as 32 percent in samples without verification (Figure 6).

On the encouraging side, these suspected errors are not persistent across all years or locations that lack visceral examinations of the fish. For the years examined, sex ratios reported for the District 1 commercial fishery have been near or within the range found in the verified samples (Figures 5 and 6). Escapement samples from Kogrukluk River were also near or within the expected range. Data from Districts 4 and 5 however show considerable divergence from expected ratios, but not in all years.

The difference between the results from District 1 and those of Districts 4 and 5 are probably due in most part to the level of experience and training provided to the people who are collecting the samples. The sampling crews in District 1 typically includes one or more experienced biologist who closely monitor the sampling routine and periodically examine a small number of fish internally to verify sex. The findings of these occasional dissections are usually shared with others on the crew as a training tool.

Kuskokwim Bay crews have not been as fortunate. Technicians sampling in Districts 4 and 5 have traditionally been more isolated and rarely had the benefit of a biologist in attendance. These fisheries are also more remote, crew size is usually smaller, sampling conditions more difficult, and crewmembers often have much less experience or training to draw on. Efforts to resolve some of these problems began in 1997 when much of the sampling responsibility shifted to Bethel where fish are sampled when delivered to local processors. Although logistically challenging, the quality and quantity of the data have improved. Additional training opportunities have been made available by rotating staff between Bethel and Kuskokwim Bay.

Length Composition

The length frequency distributions of the three most predominant Chinook salmon age classes (age-1.2, -1.3, and -1.4) overlap as illustrated in Figures 7, 8 and 9. The most distinctive group is the age-1.2 fish. This age class is comprised mostly of males and the relatively small size of the fish is one of the external morphological characteristics that can help in sex determination. The age-1.3 group contains a few more females, however female lengths tend to be limited to the upper half of the range for that age class (Molyneaux and DuBois 1999); for example, in 1999 the District 1 males averaged 675 mm in length while females averaged 801 mm. The same trend occurs in Distinct 4 where males averaged 694 mm and females averaged 802 mm, and Distinct 5 where males averaged 701 mm and females averaged 781 mm. The lengths of age-1.4 males and females overlap broadly.

Bigler et al. (1996) reported a significant decrease ($P< 0.01$) in the average weight of Kuskokwim River Chinook salmon between 1975 and 1993, however this finding is flawed for the same reason described above regarding age composition. The authors relied on commercial catch statistics and did not account for mesh size restrictions imposed beginning in 1985. A review of escapement data from Kogrukluk River shows contrary trends with the average length of age-1.2 and -1.3 males generally increasing between 1984 and 1997, while females did not show a change (Figure 10).

SOCKEYE SALMON

Age Composition

Eleven age classes have been reported for sockeye salmon returning to the Kuskokwim Area, however the most predominant group is age-1.3. The second most prevalent age class in Kuskokwim Bay is age-1.2 and in the Kuskokwim River is age-2.3. Samples from 1999 show that age-1.3 fish tend to be in greatest proportion early in the season in Kuskokwim Bay and the occurrence of age-1.2 sockeye salmon increased as the season progressed (Figure 11). Similar patterns are apparent in previous years (Molyneaux and DuBois 1998, 1999).

Length Composition

The range of lengths found in the various sockeye salmon age classes overlap broadly, however escapement data collected from the Kanektok River in 1997 show the average length for age-1.3 fish to be consistently greater than age-1.2 fish (Figure 12). Furthermore, males tend to average about 20 mm greater in length than females of the same age class. The average length of age-1.3 sockeye salmon was fairly uniform in the Kanektok River escapement throughout the season, whereas age-1.2 fish were generally smaller at the start of the season.

CHUM SALMON

Age Composition

Chum salmon return to the Kuskokwim Area at age-0.2, -0.3, -0.4, and -0.5, with age-0.3 and -0.4 most predominant. The older fish tend to arrive earlier in the season with younger fish becoming more prominent as the season progresses. The daily incidence of age-0.4 chum salmon may be as high as 90% early in the season and less than 10% near the end of the season. This pattern is well illustrated in the historical data for the Tuluksak River (Figure 13) and similar patterns have been reported in streams of the Yukon drainage (Melegari 1996; Tobin and Harper 1995), southcentral Alaska (Helle 1979), southeast Alaska (Clark and Weller 1986), British Columbia (Beacham 1984; Beacham and Starr 1982), and Washington (Salo and Noble 1953). This pattern appears to be the norm for chum salmon. Occasional inconsistencies seen in historical age summaries of the Kuskokwim Area should be viewed with some skepticism. Ideally the scales collected from such data sets should be reviewed for confirming the age determinations.

Sex Composition

The overall annual sex ratio of most Kuskokwim Area chum salmon populations approximates one male to one female. At any given location, males tend to be more predominant early in the season whereas the proportion of females increases as the season progresses. Results from Tuluksak River weir illustrate the point well with the daily percentage of females showing a steady increase as the season progresses from 25 to about 75 percent in each of four consecutive years (Figures 14). Results from both escapement and commercial samples in 1999 show the same overall trend (Figure 15). These patterns are common, if not the standard, in chum salmon populations (Bakkala 1970).

Kogrukluk River, however, is an exception to these norms. The annual percentage of females reported at the weir has always been less than 50 percent (Figure 16). Furthermore the percentage has been on a declining trend since 1981 with a record low in 1997 when females accounted for only four percent of the total run. That year is also noteworthy in that the weir had the lowest overall passage of chum salmon yet recorded for the project, still the low occurrence of females does not appear to be density dependent.

The inseason trend in female chum salmon occurrence at Kogrukluk River is also often contrary to the norm. In 9 of 12 seasons reported the proportion of females either decrease as the season progresses, or shows little change (Figure 17).

The cause of the sex ratio anomaly at Kogrukluk River is unknown. Commercial harvest is a potential factor, however the sex ratio in the commercial fishery is only slightly higher for females than males (Figure 16), and other spawning stocks do not show a female composition on the order of the Kogrukluk River. Furthermore, the lowest proportion of females yet reported from the weir project occurred in 1997 when only one limited commercial fishing period was allowed for chum salmon (Burkey et al. 1997).

Another possible explanation is related to the location of the Kogrukluk River (Figure 1). The stream is found in the headwaters of the Holitna River drainage and there are abundant spawning grounds downstream of the Kogrukluk River, including the main stem of the Holitna River. Schroder (1982) reported that male chum salmon remain sexually active for 10 to 14 days while most females complete their spawning in only 1 or 2 days. If during their prolonged activity, male chum salmon continued to migrate upstream while females remained more stationary, then that would account for the higher proportion of males seen passing Kogrukluk River weir. The fact that the proportion of females rarely increases with the progression of the run further supports this explanation. Although plausible, this hypothesis fails to explain the trend of declining percentages observed over the past seventeen years (Figure 16).

Length Composition

The length frequency of chum salmon overlap broadly by age and sex groupings, however the average length of females is generally less than males of the same age class. Also, Kuskokwim Bay chum salmon tend to be larger at age than Kuskokwim River fish as illustrated in Figure 18 for 1999. Another common pattern in Kuskokwim Area chum salmon is that as the migration progresses the average length of new arrivals tends to decrease for all age-sex groupings. At Tuluksak River the average decrease in length over the course of the run was on the order of 56 mm (Figure 19).

Bigler et al. (1996) have reported significant decreases in the average weight at age for many Alaskan and North Pacific chum salmon populations between 1975 to 1993, including the Kuskokwim River ($P < 0.05$). The authors' conclusion generally relies on commercial catch statistics, which, for the Kuskokwim River, contain some confounding influences. First, prior to 1985 there were no restrictions on the mesh size fishers used and their tendency to use larger mesh sizes for targeting Chinook salmon would have also resulted in a higher proportion of larger chum salmon in the catch. Beginning in 1985 the mesh size was restricted to six inches or smaller (Burkey et al. 1999), which would have reduced the average size of chum salmon in the harvest. Second, beginning in the late 1980s there was a growing tendency to extend the commercial fishing season for chum salmon into the second half of July when the average size of chum salmon tends to be smaller due to higher proportions of younger age classes and females in the catch, both of which are smaller in size, and due to the tendency of the average size of all age-sex groups to decrease as the season progresses. Third, as the value of chum salmon has decreased over the past several years (Burkey et al. 1999), some fishers are beginning to use smaller mesh sizes which tend to be more effective in catching the higher valued sockeye salmon (author's observation). In contrast to the findings of Bigler et al. (1996), chum salmon data from Kogrukluk River escapements and the District 1 commercial harvests both show variable average lengths at age over the years, but no decreasing trend (Figure 20).

COHO SALMON

Age Composition

Coho salmon return to Kuskokwim Area streams at age-1.1, -2.1 and -3.1. Age-2.1 fish usually account for more than 90% of the return. Age-3.1 normally compose five percent or less of the return. An exception to this trend occurred in 1999 when an atypically higher percentage of age-3.1 coho returned to the Kuskokwim River. Age-3.1 comprised 13.2% of the harvest in District W1, 12.9% of the return to Tatlawiksuk River and 27.4% of the return to George River.

Since 1997 there has been an effort to reduce the number of coho scales collected for age determination to one strata sample size collected across each quarter or third of the run. Given the overwhelming dominance of age-2.1 fish additional samples were considered unnecessary. Any additional sampling effort for the commercial fisheries is limited to collecting sex and length data.

Sex Composition

Sex was confirmed through internal examination in most coho salmon sampled from the commercial harvest starting in 1997. These samples generally exhibited an increasing proportion of females in the catch as the season progressed (Figure 21). The pattern is not always obvious in other databases, possibly because of errors in sexing the fish. Female coho salmon sometimes have some level of kype development that can confound sexing by external characteristics alone.

Length Composition

No consistent pattern is obvious in the average length composition at age with coho salmon. Overall, the mean length of fish does tend to increase as the season progresses, but the pattern is not consistent for all years. There is a pattern, however, of female coho salmon tending to be larger than males. The mean lengths of District 1 samples with confirmed sex identification from 1997 and 1998 were pooled over all age classes by year and compared by sex. The mean length of females was found to be significantly greater in both years. In 1997 the mean length was 562 mm for males and 571 mm for females (two-tailed t-test; $P = 0.00069$, df 700). In 1998 the mean length was 567 mm for males and 574 mm for females (two-tailed t-test $P = 0.00026$, df 1154). This pattern is not apparent in the historical database where sex was not confirmed, which adds further question to the reliability of sex determination of coho salmon when the sex is not confirmed.

CONCLUSIONS

- The objective for FIS 04-307 was fulfilled for 2004. ASL data were compiled across projects collecting samples in the Kuskokwim Area in 2004.
- The ASL catalog comprised of 128 tables, 832 pages and is available electronically from the Division of Commercial Fisheries, Kuskokwim Area web page at: http://www.cf.adfg.state.ak.us/region3/pubs/pubshom3.php?a=w .

RECOMMENDATIONS

- Stabilize standardized collection and processing of salmon ASL data to ensure that an adequate time series of data is maintained that will facilitate retrospective analysis
- Facilitate retrospective data analysis by continuing to report the salmon ASL time series in a manner that allows for broad and easy access to the data sets.
- Continue to process ASL samples in a centralized location with consistent aging criteria and data processing methods.
- Continue to archive scale cards, paper data collection forms, and electronic data in a centralized location.
- Continue to add historical data summaries to the catalog with the goal of summarizing all data historically collected in the Kuskokwim Area.
- Improve how tables in the ASL catalog are compiled. Currently the compilation of the catalog, which represents 833 pages and 128 tables, is cumbersome. Automating the

importation of Excel spreadsheet tables, preparation of the table of contents, and pagation in Adobe Acrobat would be a start.

- Update figures to include data since 1999, as well as illustrations of other data sets.

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TABLES AND FIGURES

Table 1.- Distance to selected locations from the mouth of the Kuskokwim River or Bethel.

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Popokamiut (Downstream boundary District 1)	(3)	(2)	(109)	(68)
Kuskokwim River Mouth [c]	0	0	(106)	(66)
Apokak Slough (Downstream boundary District 1)	5	0	(106)	(66)
Eek River	13	8	(93)	(58)
Eek (community)	46	29	(60)	(37)
Kwegooyuk	22	13	(85)	(53)
Kinak River	32	20	(74)	(46)
Tuntutuliak (community)	45	28	(61)	(38)
Kialik River	50	31	(56)	(35)
Fowler Island	68	42	(39)	(24)
Johnson River	77	48	(29)	(18)
Napakiak (community)	87	54	(19)	(12)
Napaskiak (community)	97	60	(10)	(6)
Oscarville (community)	97	60	(10)	(6)
Bethel (community)	106	66	0	0
Gweek River	135	84	29	18
Kwethluk River	131	82	25	16
Kwethluk (community)	132	82	26	16
Kwethluk River Weir	216	134	109	68
Akiachak (community)	143	89	37	23
Kasigluk River	150	93	43	27
Kisaralik River	151	94	45	28
Akiak (community)	161	100	55	34
Mishevik Slough,	183	114	77	48
Tuluksak River	192	119	85	53
Tuluksak (community)	192	120	86	54
Tuluksak River Weir	248	154	142	88
Nelson Island	190	118	84	52
Bogus Creek (Upstream Boundary District 1)	203	126	97	60
High Bluffs	233	145	127	79
Downstream Boundary District 2	262	163	156	97
Mud Creek Slough	267	166	161	100
Lower Kalskag	259	161	153	95
Kalskag (community)	263	163	157	97
Lower Kalskag Fishwheel (2004)	249	155	143	89
Kalskag Fishwheel (2002, 2003, and 2005)	270	168	163	102
Birchtree Fishwheel (2001 to 2004)	294	183	187	117

-continued-

Table 1.- Page 2 of 3.

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Aniak River	307	191	201	125
Aniak (community)	307	191	201	125
Aniak Receiver Site (upper)	310	191	201	125
Aniak Receiver Site (lower)	306	191	201	125
Aniak Sonar Site	323	201	217	135
Aniak Sonar Receiver Site	323	201	217	135
Chuathbaluk (community)	323	201	217	135
Upstream Boundary District 2	322	200	216	134
Kolmakof River	344	214	238	148
Napaimiut (community)	359	223	253	157
Holokuk River	362	225	256	159
Sue Creek	381	237	275	171
Oskawalik River	398	247	291	181
Crooked Creek (community)	417	259	311	193
Georgetown (community)	446	277	340	211
George River	446	277	340	211
George River Weir	453	281	347	215
George Receiver Site	453	281	347	215
Red Devil (community)	472	293	365	227
Red Devil Receiver Site	472	293	365	227
Sleetmute (community)	488	303	381	237
Holitna River	491	305	385	239
Hoholitna River	538	334	432	268
Chukowan River	709	441	603	375
Kogrukluk River	709	441	603	375
Kogrukluk River Weir	710	441	604	375
Kogrukluk Receiver Site	710	441	604	375
Stony River (community)	534	332	428	266
Stony River	536	333	430	267
Lime Village (community)	644	400	538	334
Telaquana River	727	452	621	386
Telaquana Lake (outlet)	756	470	650	404
Swift River	560	348	454	282
Tatlawiksuk River	563	350	457	284
Tatlawiksuk River Weir	568	353	462	287
Tatlawiksuk Receiver Site	568	353	462	287
Devil's Elbow	599	372	492	306
Vinasale (abandoned community)	665	413	558	347

-continued-

Table 1.-Page 3 of 3.

Location [b]	Distance From River Mouth [c]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Takotna River	752	467	645	401
Takotna (community)	832	517	726	451
Takotna River Weir	835	519	729	453
Takotna Receiver Site	835	519	729	453
McGrath (community)	753	468	647	402
McGrath Receiver Site	753	468	647	402
Middle Fork	806	501	700	435
Big River	827	514	721	448
Pitka Fork	845	525	739	459
Medfra (community)	863	536	756	470
South Fork	869	540	763	474
East Fork	882	548	776	482
North Fork	884	549	777	483
Nikolai (community)	941	585	835	519
Swift Fork	1,078	670	972	604
Telida (community)	1,128	701	1,022	635
Highpower Creek	1,151	715	1,044	649
Headwaters South Fork	1,292	803	1,186	737
Headwaters North Fork	1,548	962	1,442	896

[a] Distances are determined using a computer version (Garmin Topo MapSource) of U.S. Geological Survey 1:100,000 scale maps. Routing is as if traveling by boat.

[b] Locations not on the mainstem of the Kuskokwim River are listed as subordinate to the point of departure from the mainstem.

[c] The "mouth" of the Kuskokwim River is defined as the southern most tip of Eek Island (latitude N 60° 05.569, longitude W 162° 19.054), and is one of three points that define the downstream boundry of District 1.

Note: Distances to radiotelemetry tracking stations are approximate.

Table 2.-Projects and salmon species for which age sex, and length data are summarized in the 2004 Kuskokwim Area ASL Catalog.

		Salmon Species (ASL Summaries Present = X)			
Project Type	**Location**	**Chinook**	**Sockeye**	**Chum**	**Coho**
Escapement	Takotna R.	X		X	X
	Tatlawiksuk R.	X		X	X
	Kogrukluk R.	X		X	X
	George R.	X		X	X
	Aniak R.			X	X
	Tulusak R.	X	X	X	X
	Kisaralik R.	X			
	Kwethluk R.	X	X	X	X
	Kanektok R.	X	X	X	X
	Goodnews R.	X	X	X	X
Commercial	District 1	X	X	X	X
	District 4	X	X	X	X
	District 5	X	X	X	X
Test Fish	Bethel Test Fish	X	X	X	
Subsistence	Kuskokwim R.	X			

Figure 1.- Kuskokwim Management Area (W) and commercial fishing districts in the Kuskokwim River (W-1 and W-2).

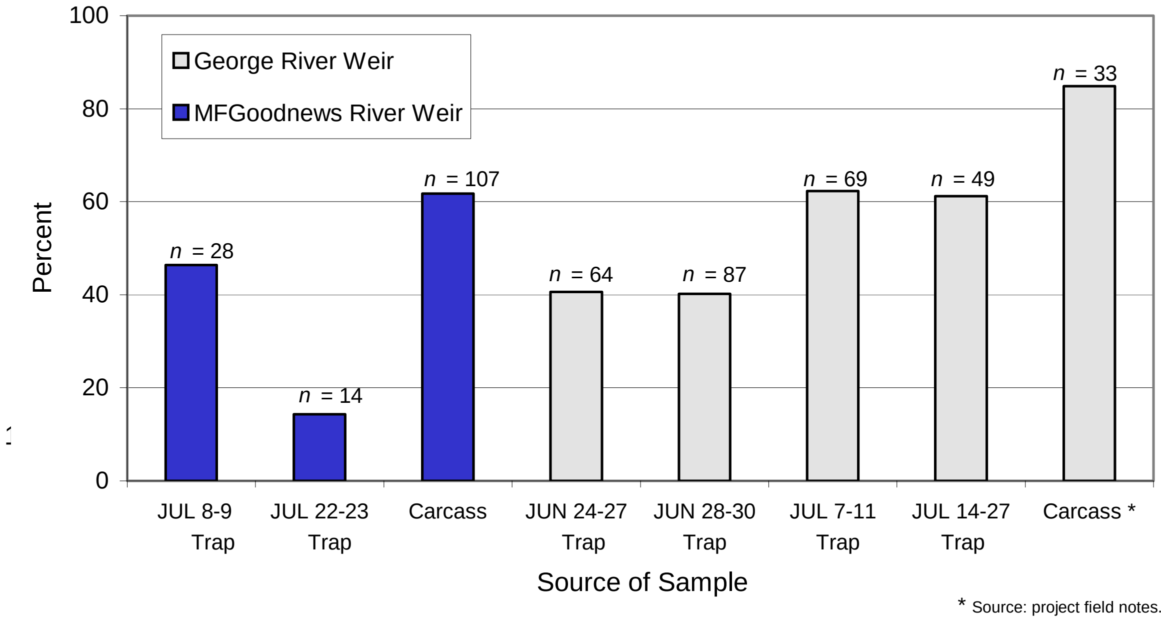

Figure 2.- Incidence of male Chinook salmon in trap and carcass samples from the Middle Fork Goodnews River weir in 1996 and the George River weir in 1997.

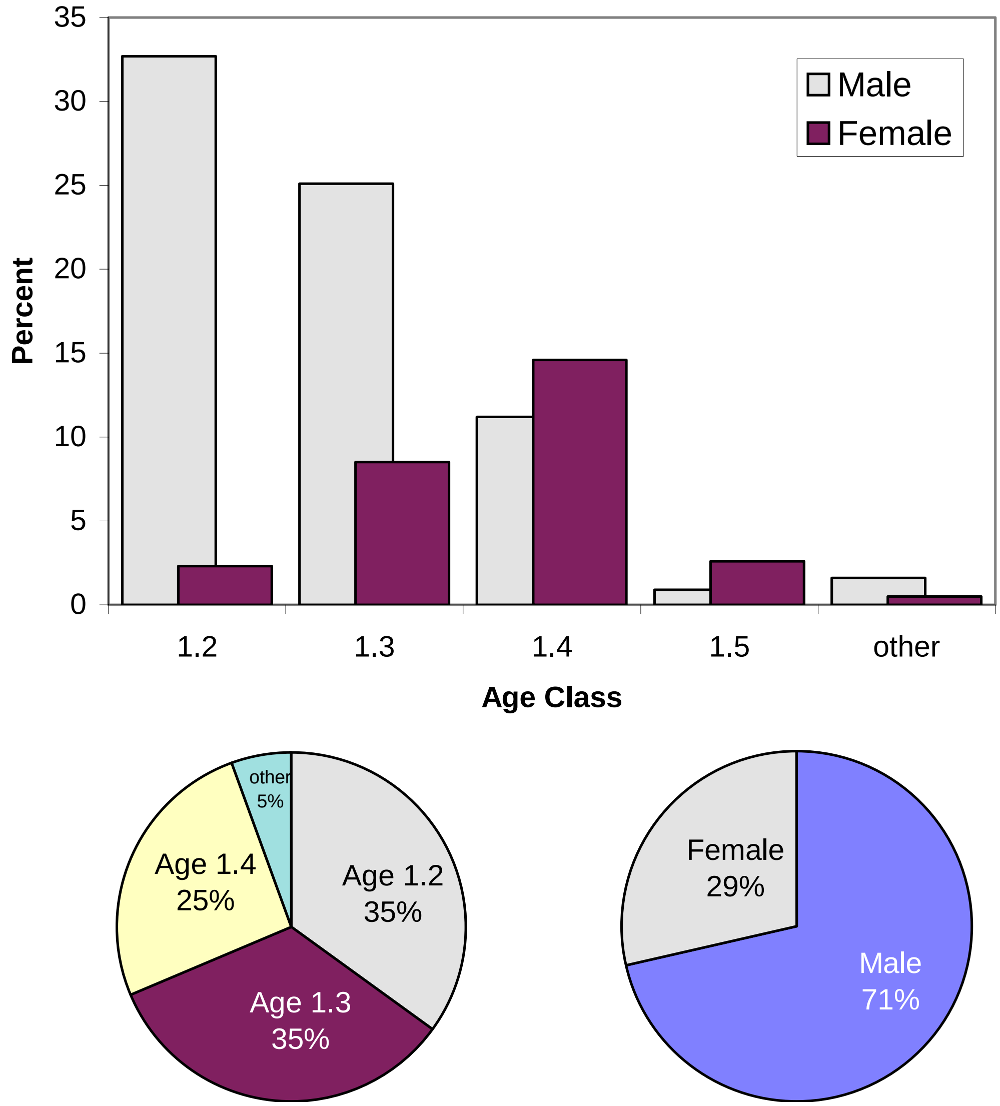

Figure 3.- Age and sex composition of District 1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was restricted to 6 inches or smaller, 1974 - 1999.

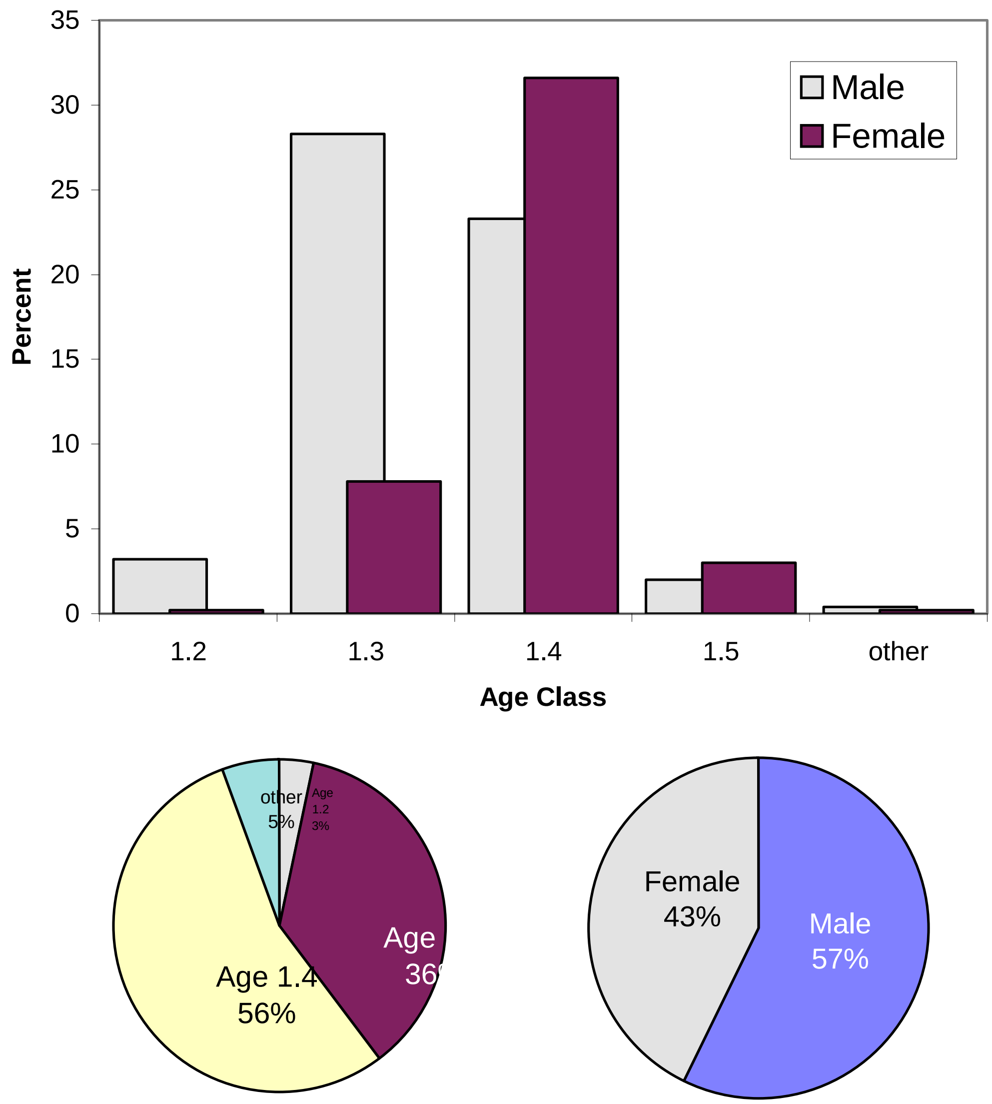

Figure 4.- Age and sex composition of District 1 Chinook salmon harvested from commercial fishing periods in which gillnet mesh size was unrestricted, 1974 - 1984.

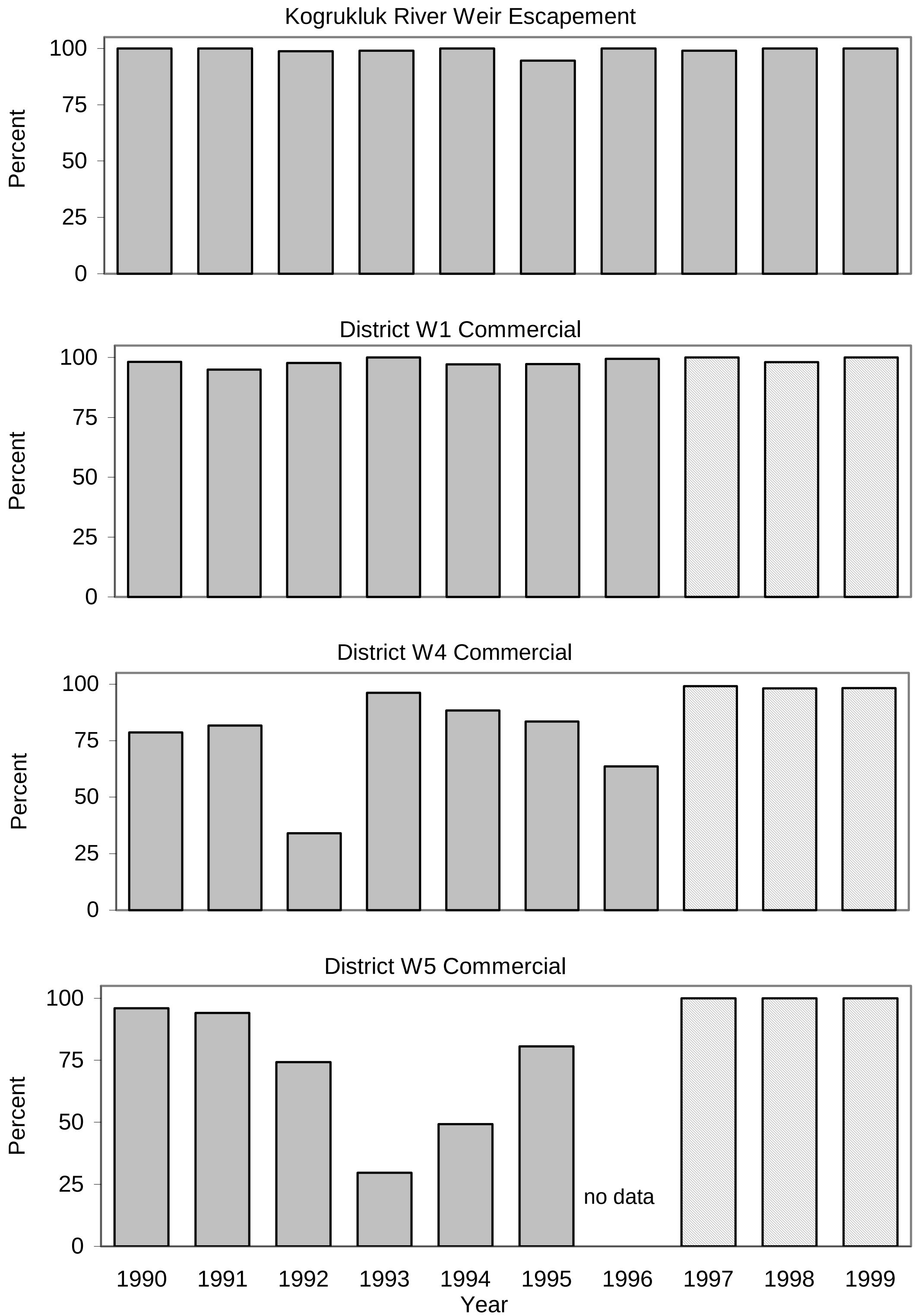

Figure 5.- Historical percentage of age-1.2 Chinook salmon reported as males from Kogrukluk River weir and Districts 1, 4 and 5, 1990-1999. Hatch-marked bars only include data for fish with confirmed sex identification.

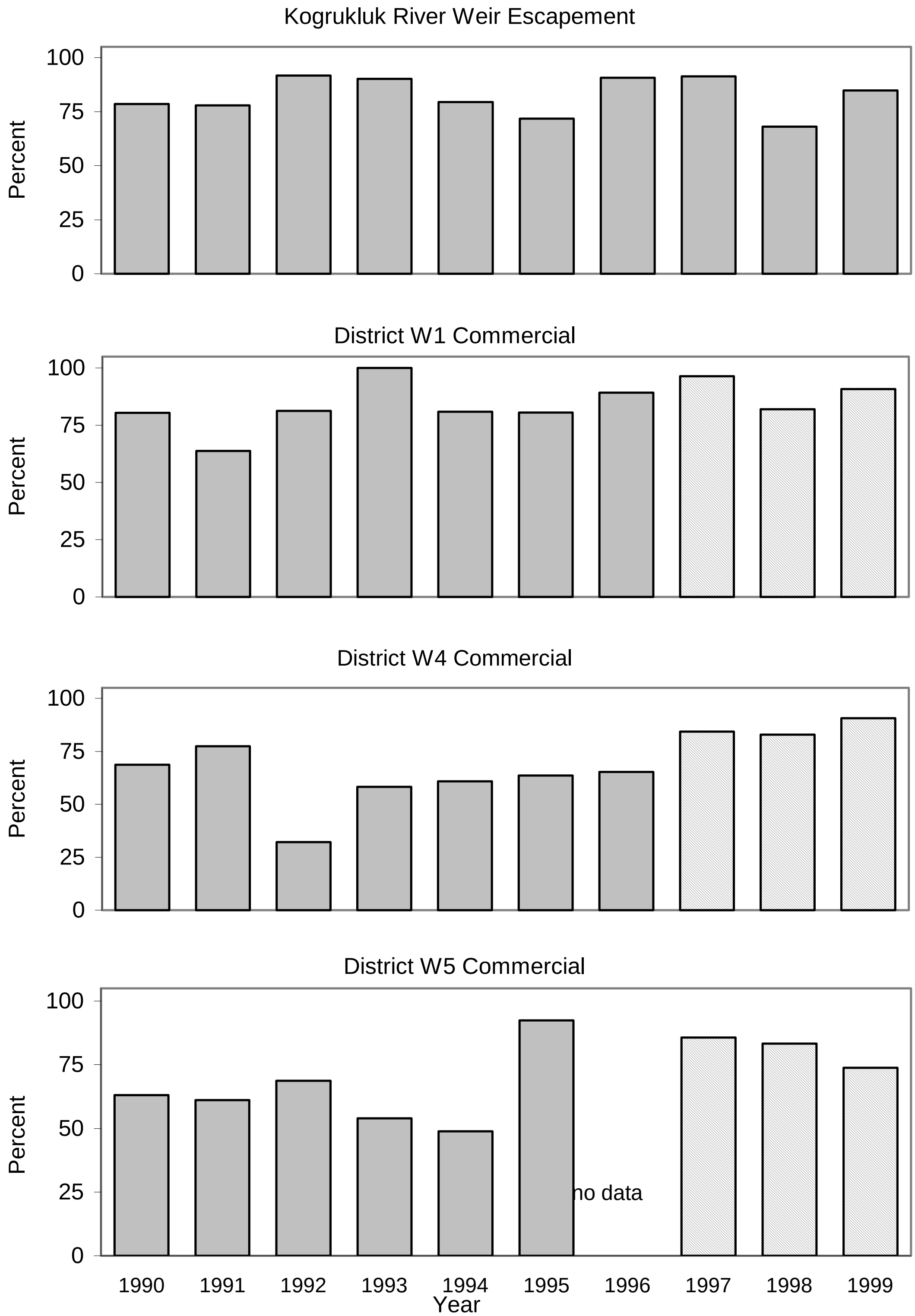

Figure 6.- Historical percentage of age-1.3 Chinook salmon reported as males from Kogrukluk River weir and Districts 1, 4 and 5, 1990-1999. Hatch-marked bars only include data for fish with confirmed sex identification.

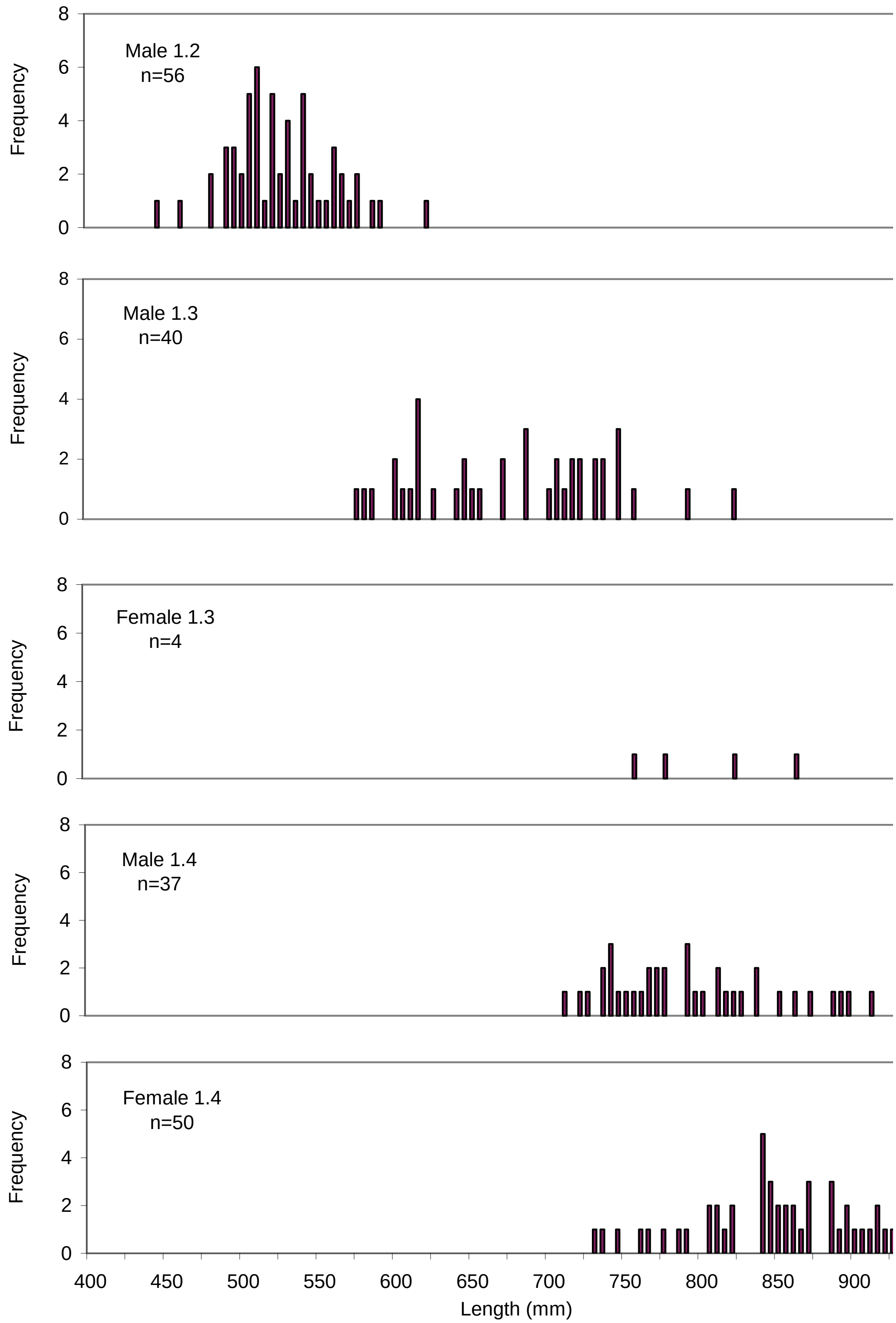

Figure 7.- Length frequency of District 1 Chinook salmon by age and sex, 1999.

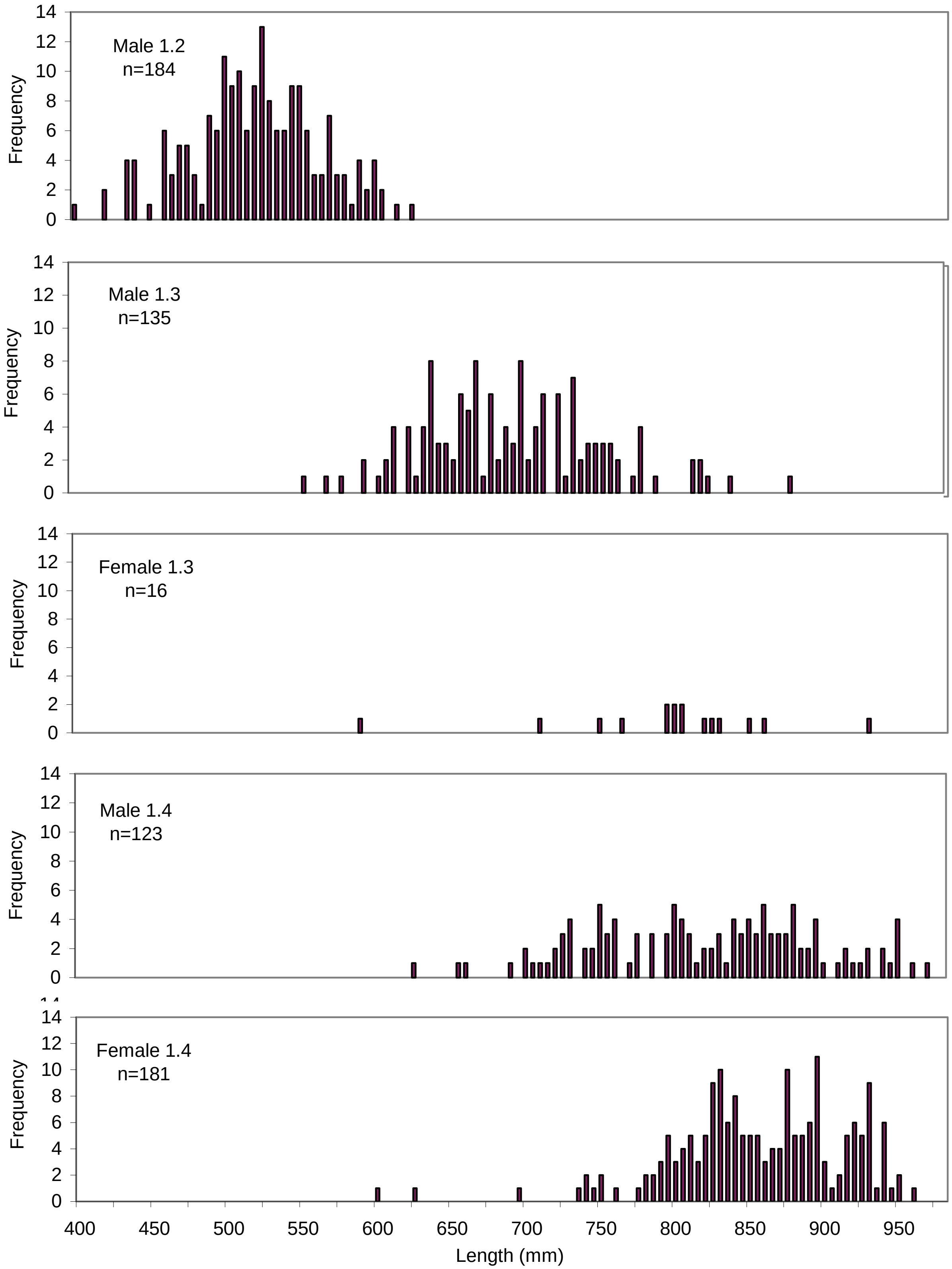

Figure 8.- Length frequency of District 4 Chinook salmon by age and sex, 1999.

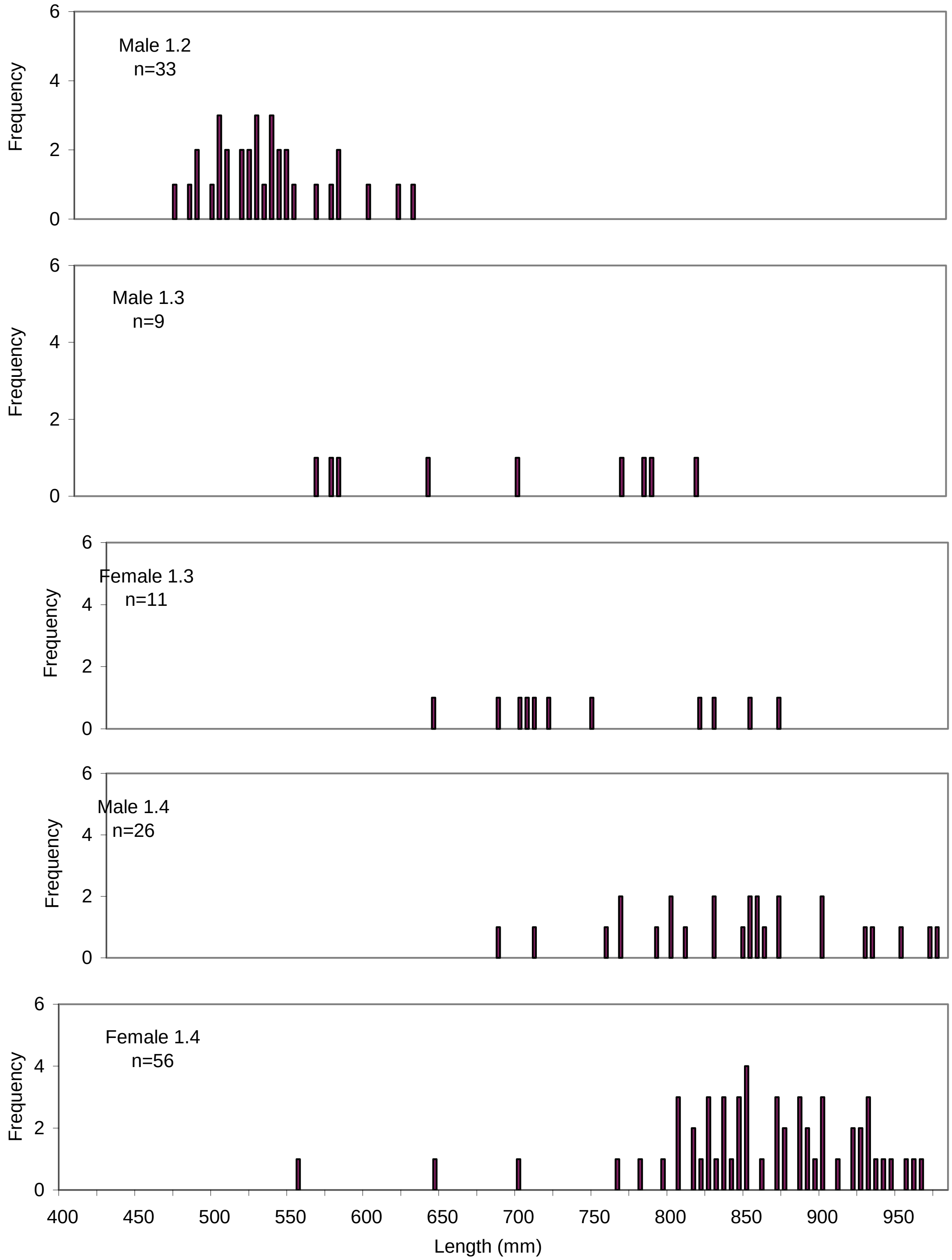

Figure 9.- Length frequency of District 5 Chinook salmon by age and sex, 1999.

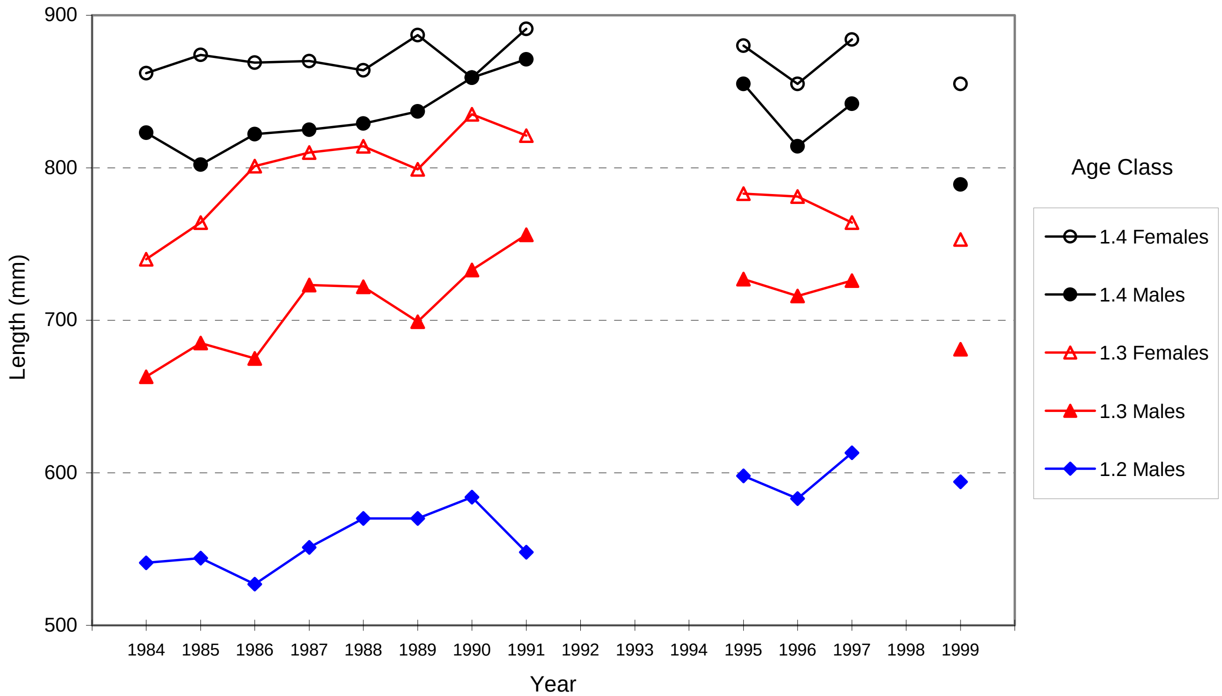

Figure 10.- Historical trends in the average length of Chinook salmon at Kogrukluk River weir, 1984-1999.

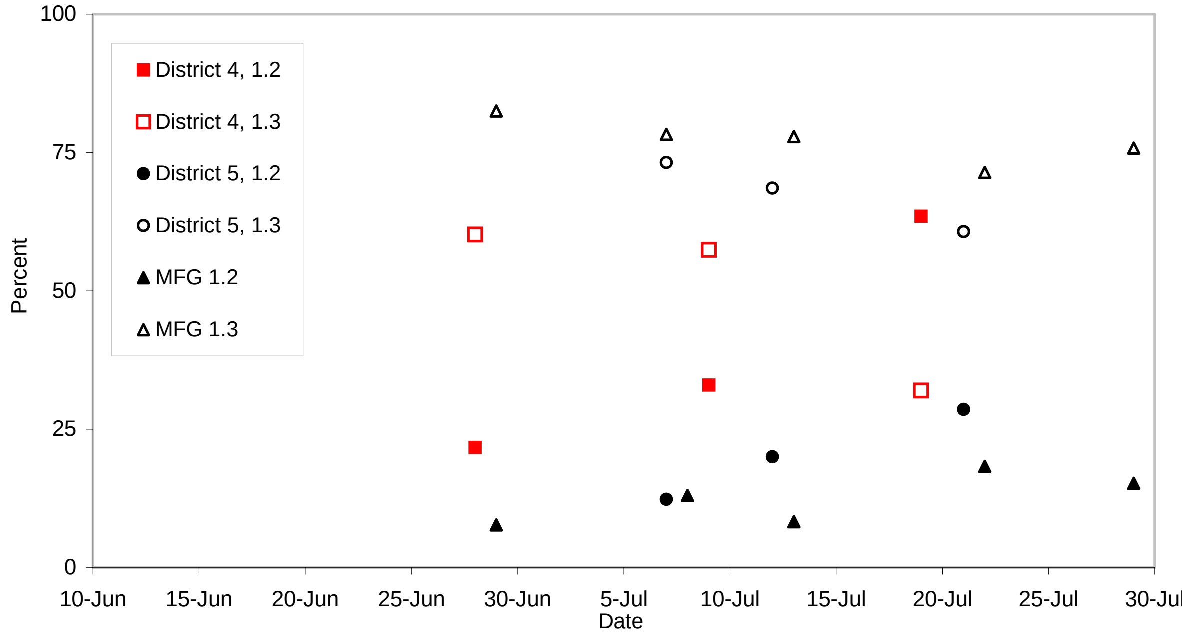

Figure 11.- Percentage of age-1.2 and -1.3 sockeye salmon by sample date from the Middle Fork Goodnews River weir (MFG) escapement and the District 4 and District 5 commercial catches, 1999.

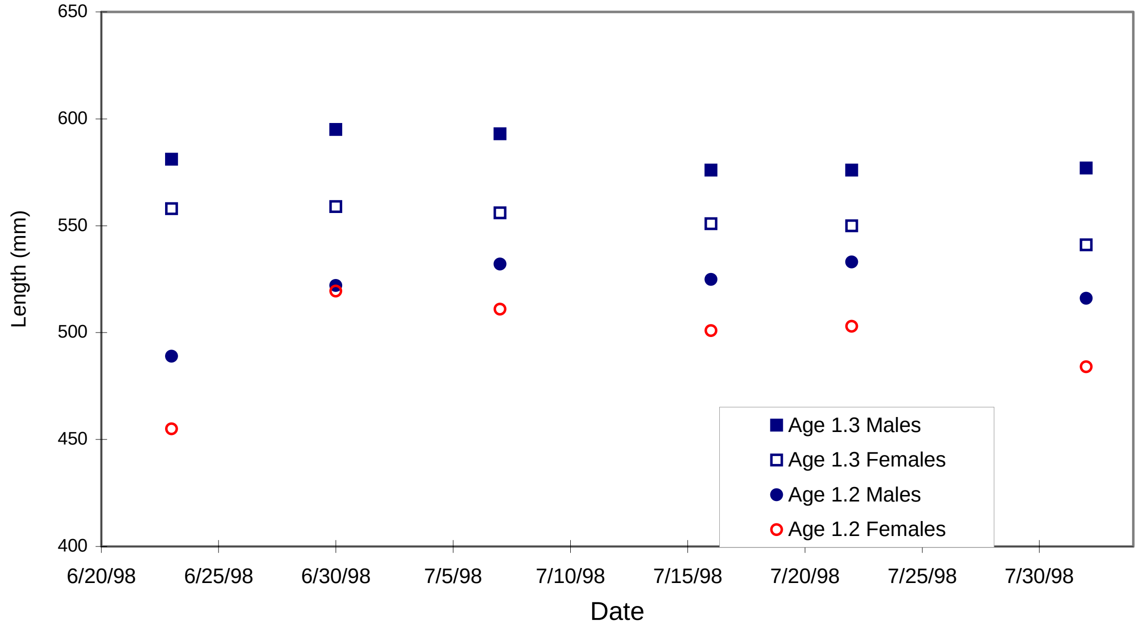

Figure 12.- Average length by sample date for Kanektok River sockeye salmon in 1997.

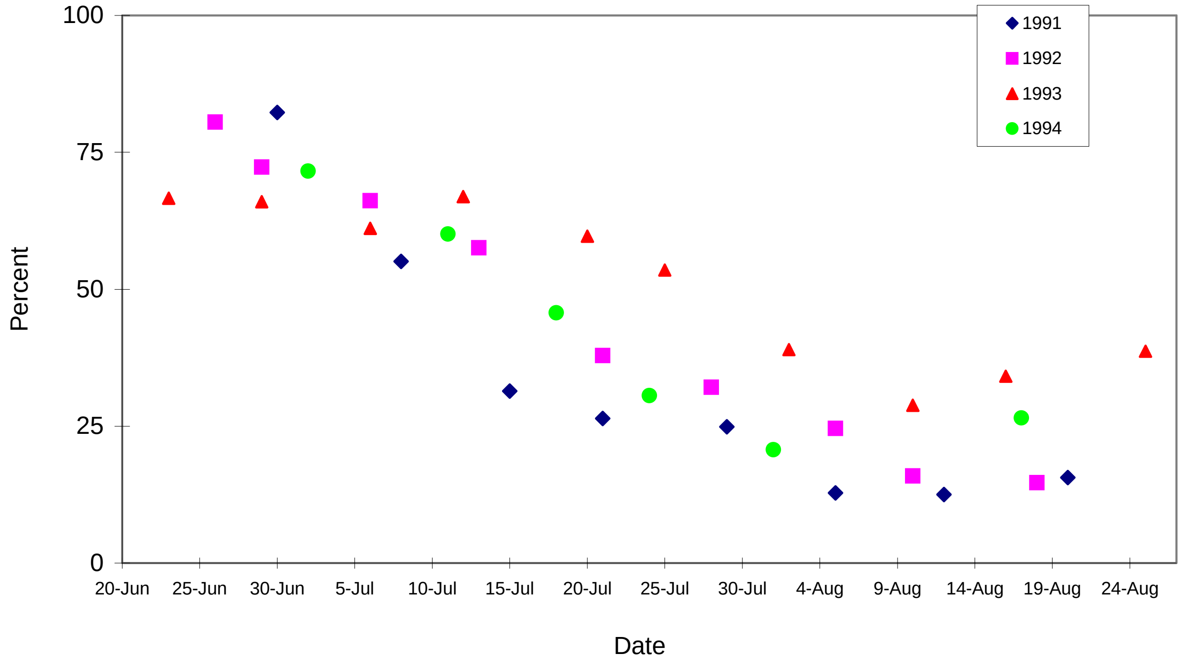

Figure 13.- Percentage of age-0.4 chum salmon by sample date in the Tuluksak River , 1991- 1994.

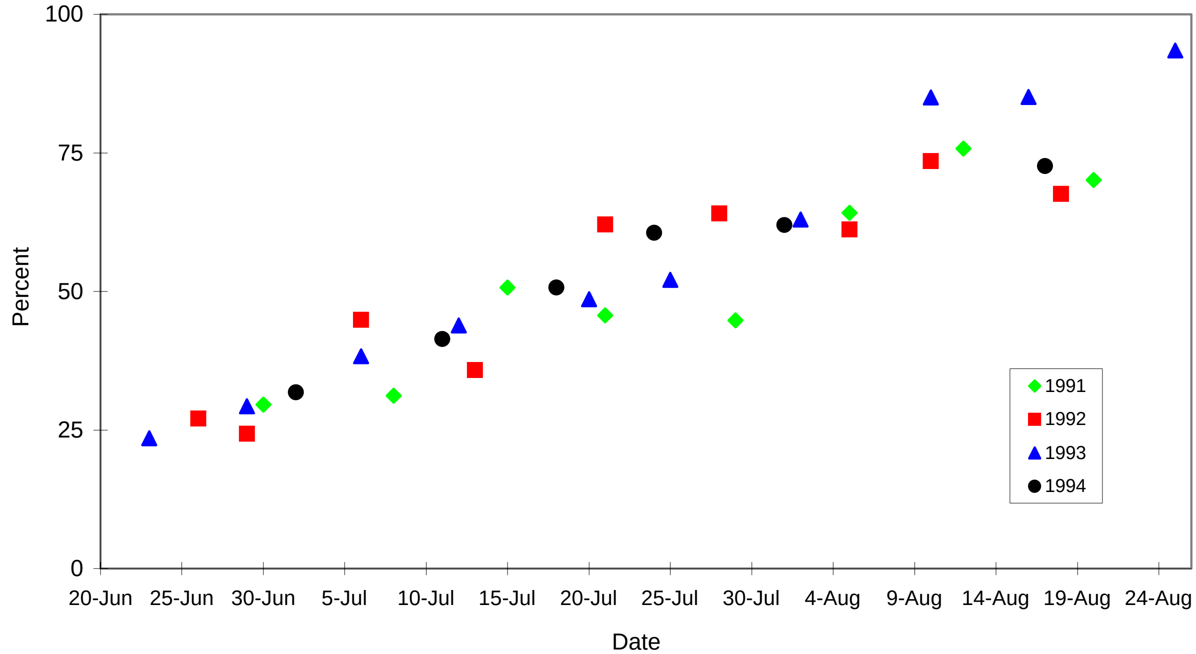

Figure 14.- Percentage of female chum salmon by sample date at Tuluksak River weir , 1991- 1994.

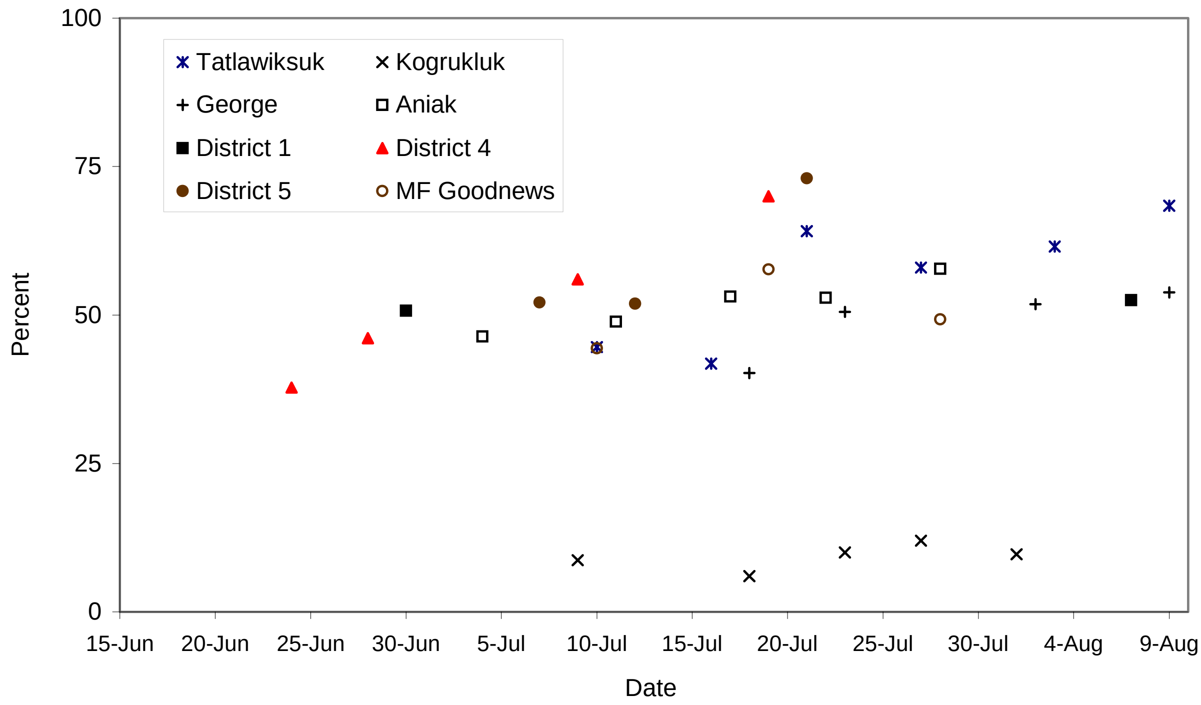

Figure 15.- Percentage of female chum salmon by sample date from Kuskokwim Area escapements and commercial catches, 1999.

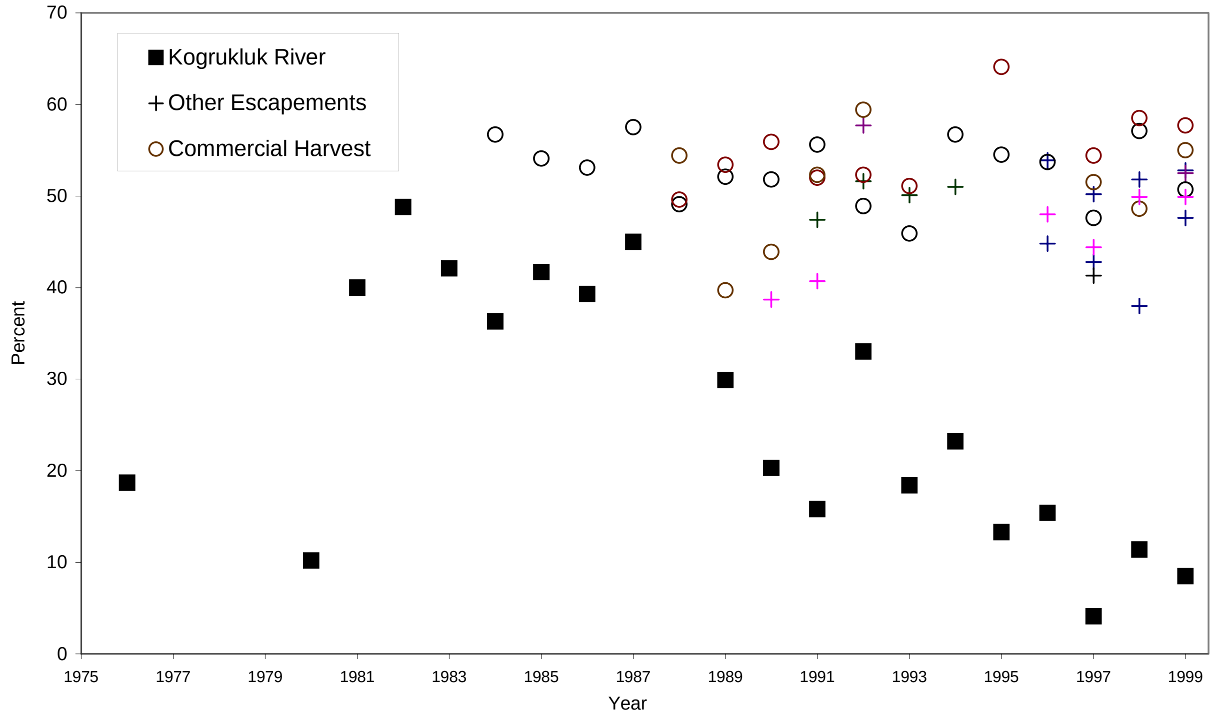

Figure 16.- Historical percentage of female chum salmon in Kuskokwim Area escapement and commercial catch, 1976-1998.

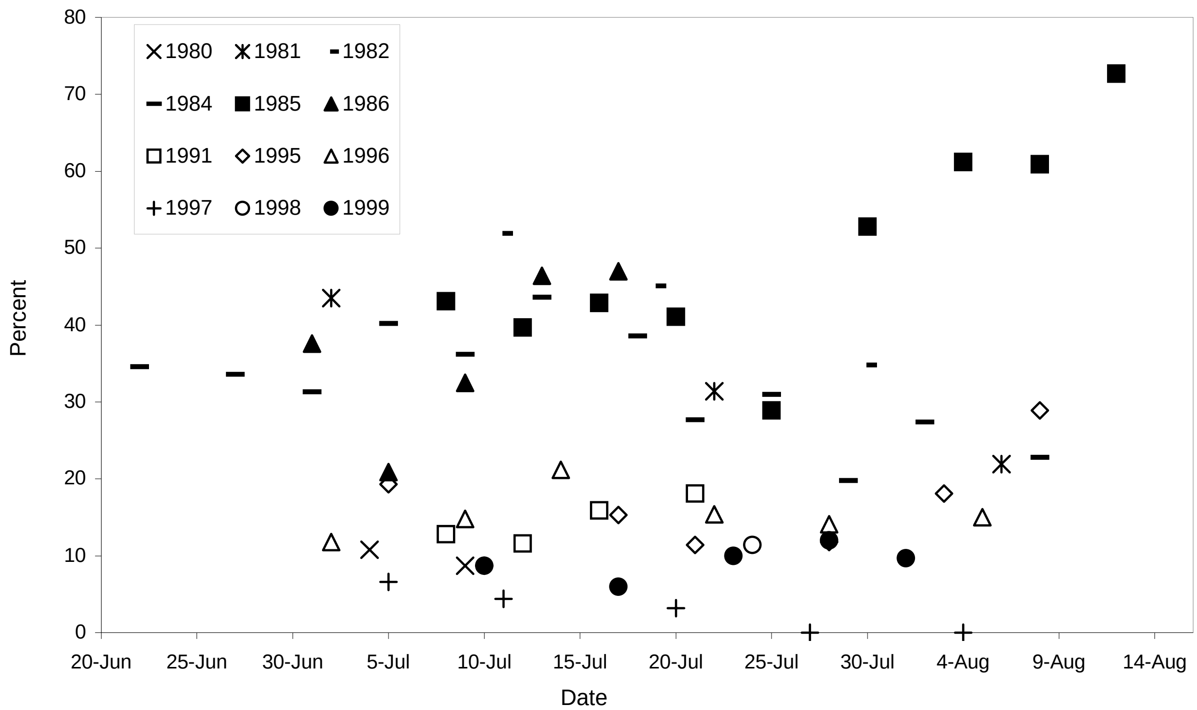

Figure 17.- Historical percentage of female chum salmon by sample date at Kogrukluk River weir, 1980-1999.

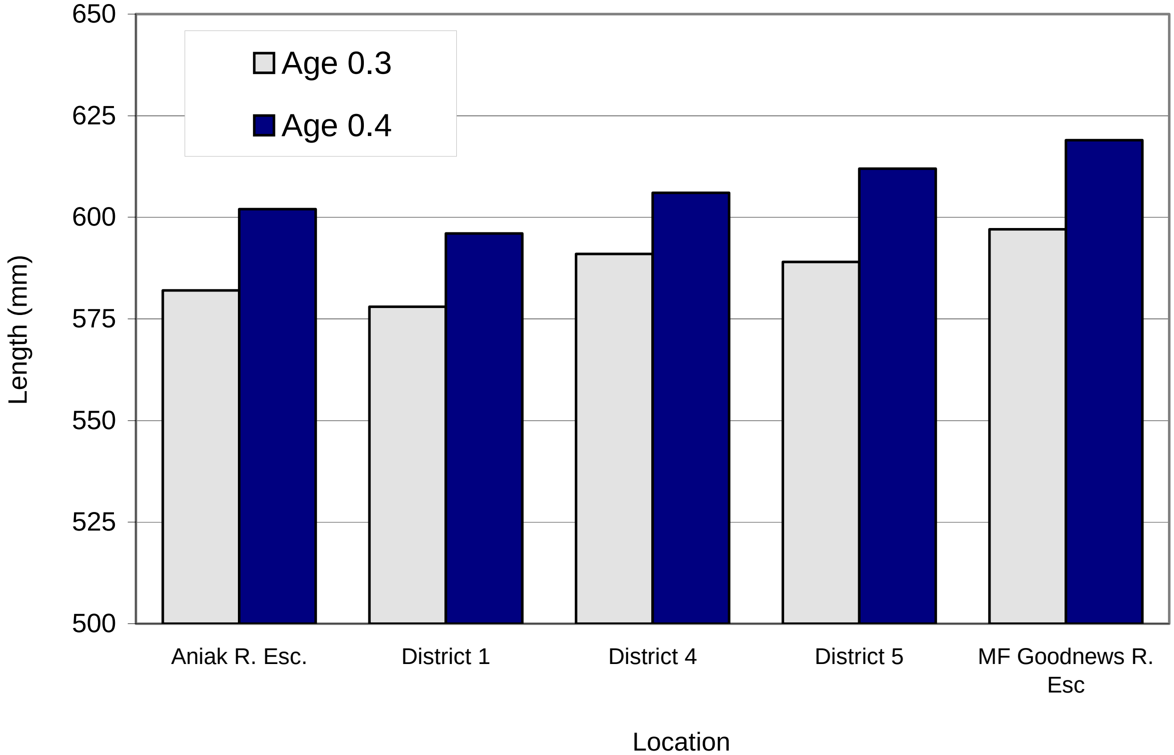

Figure 18.- Average length of male chum salmon from escapements and commercial catches in the Kuskokwim Area, 1999.

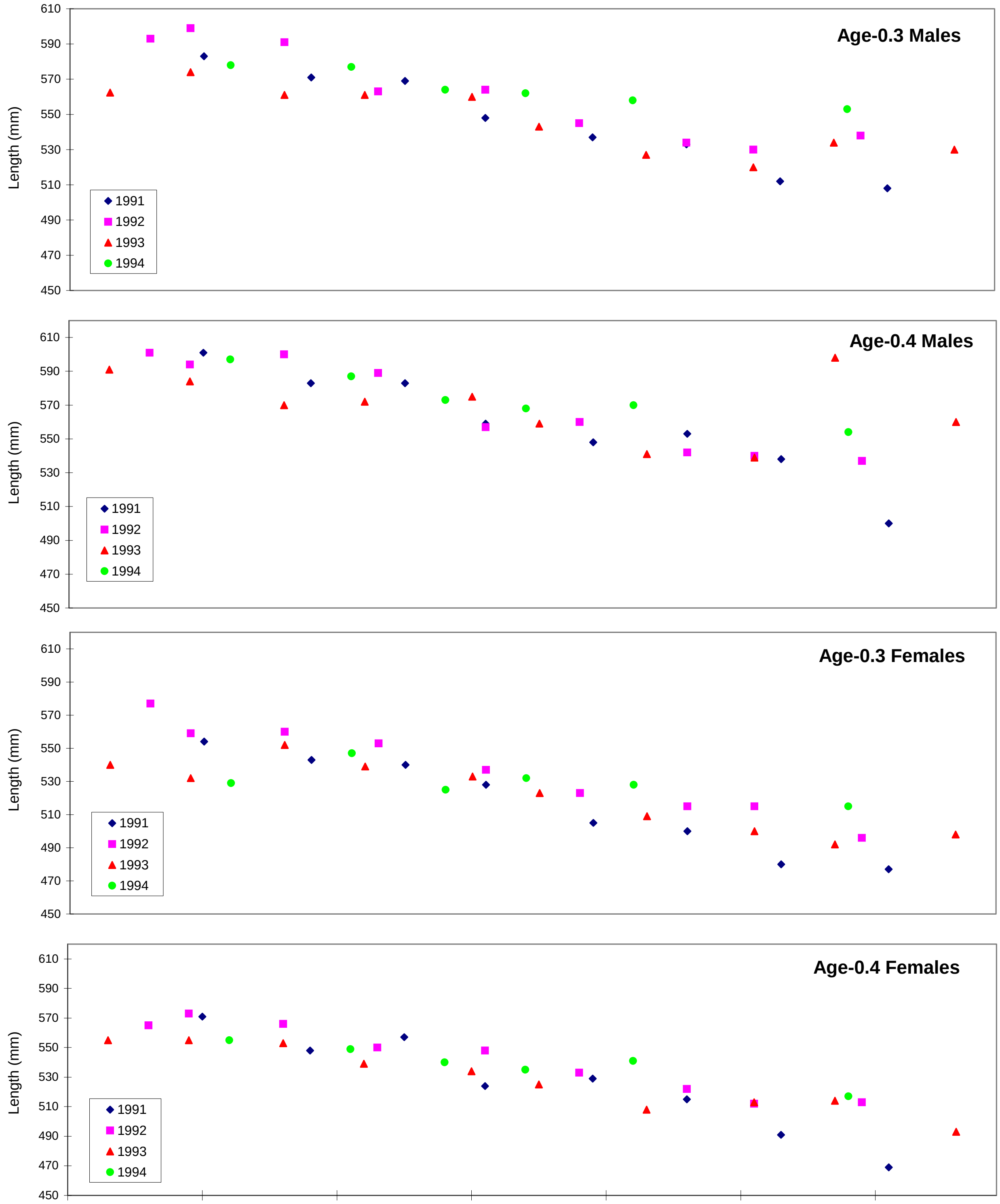

Figure 19.- Average length of chum salmon by sample date in the Tuluksak River , 1991 - 1994.

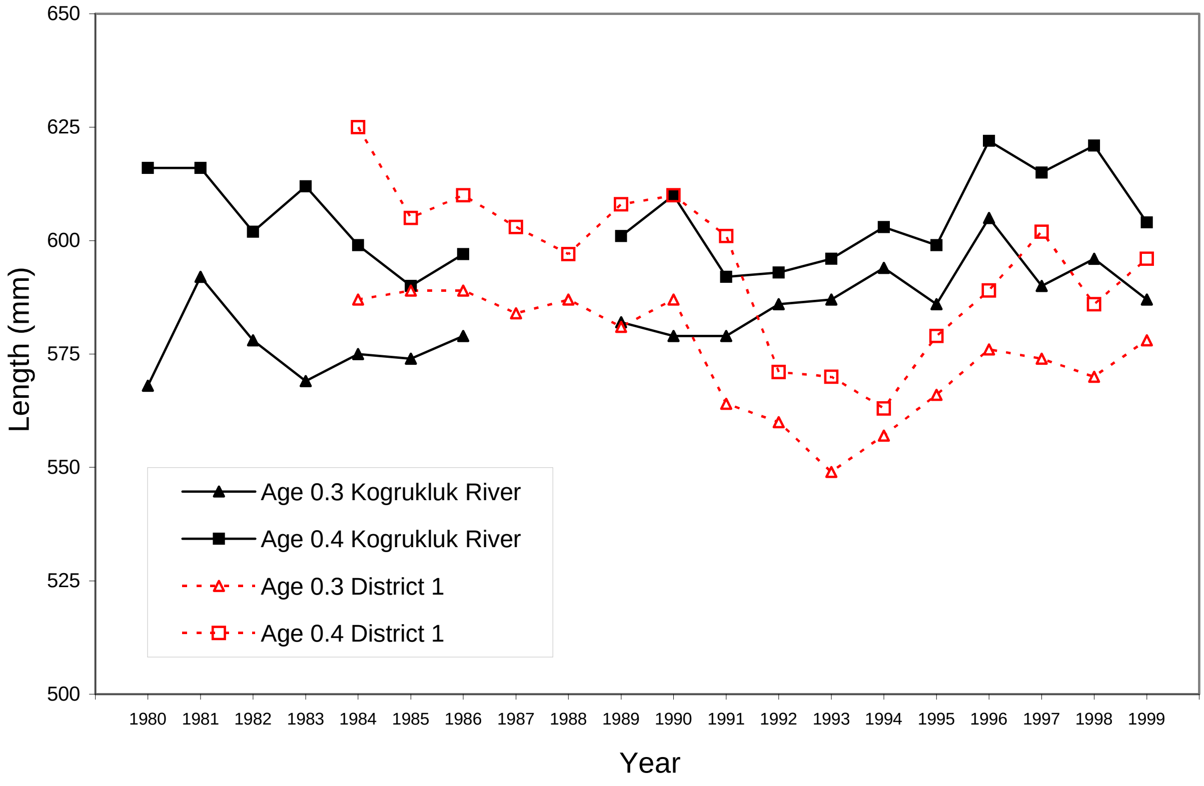

Figure 20.- Historical average length of male chum salmon from Kogrukluk River and District 1 by age, 1980-1999.

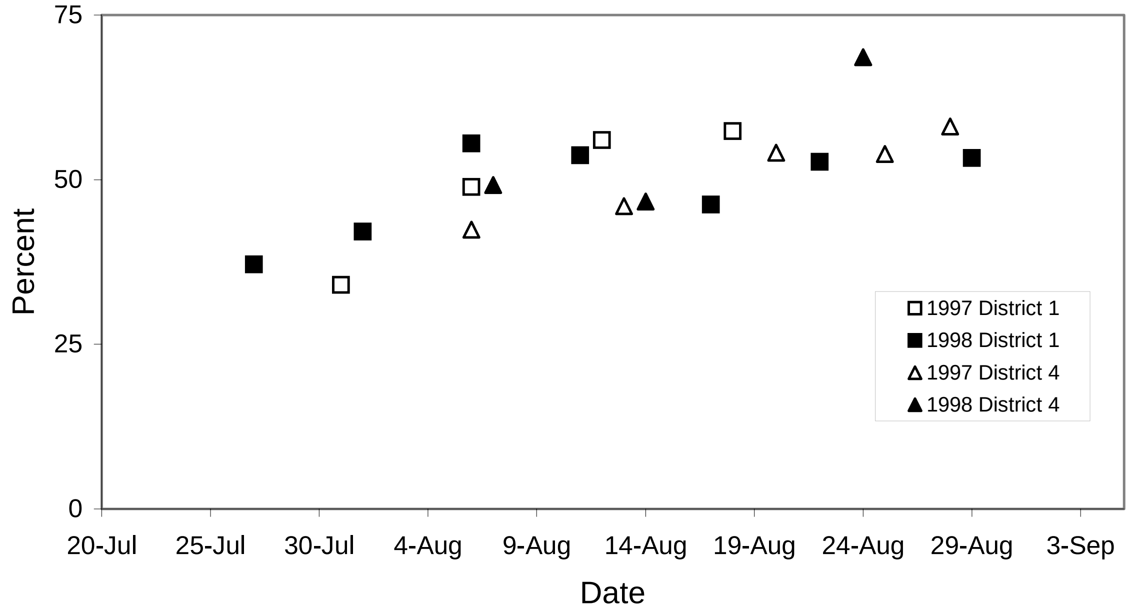

Figure 21.- Percentage of female coho salmon by sample date from Districts 1 and 4 commercial catch samples, 1997 and 1998.